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THE USE OF COMPRESSED AIR FOR OPERATING THE CONTRACTOR'S PLANT AT THE WACHUSETT DAM.*

Some of the advantages arising from the use of compressed air on contract work were outlined editorially in our issue of June 4, 1903, and now we have the pleasure of citing an object lesson that is particularly impressive, not only by virtue of the magnitude of the work involved, but also by virtue of the excellent results that have followed the use of compressed air on so large a scale.

To generate 1,000 HP. at a central plant, and to convey the power to some 80 different engines, is in itself impressive, but to have kept such a plant in continuous operation for a period of 32 months is a record that, so far as we know, has never been equaled on contract work. In view of this fact some details of the plant and its operation will be of especial interest to contractors having similar work to do.

In the first place, it should be stated that the power station, Fig. 3, is located between the dam, Fig. 1, and the quarry, Fig. 4, the distance to the dam being nearly 1¼ miles, and to the quarry half a mile. Power for operating the drills, derricks, etc., is supplied by two Rand-Corliss air compressors, of 500 HP. each. The engines are designed to operate under a steam pressure of 135 lbs., with steam cylinders 18 and 34 ins. diam. for the high and low pressure, respectively, and have a 42-in. stroke. The air cylinders of each compressor are 21 and 34 ins. diam. for the high and low pressure, respectively. At the normal speed of 75 r. p. m., each compressor delivers 3,310 cu. ft. per min. of free air raised to 90 lbs. per sq. in. The engines are so designed that either high or low pressure cylinder may be run independently. Water for the boilers is secured through a 3-in. pipe from a pond about a mile away, and condensing water is drawn from a pond alongside the power house. The compressed air is discharged through a 10-in. pipe into a horizontal air receiver 6 ft. diam. × 20 ft. long, and the air is delivered to the works at the dam through an 8-in. pipe, 6,500 ft. long.

*For full description of Wachusett Dam see Engineering News, Sept. 13, 1900.

At the present time the following engines and machines are being run with the air from this plant:

31 hoisting engines, about 16 HP. each.
2 cableway engines, about 50 HP. each.
16 No. 3 Rand drills.
3 pumps, 3 to 4-in. discharge.
1 engine on revolving screen, 10 HP.
1 engine in machine shop, 10 HP.
1 engine on mortar mixer, 10 HP.
1 pneumatic riveter.
1 trip hammer.
3 stone dressing machines.
10 blacksmiths' forges.
10 pneumatic plug drills.

80 total

While as before stated, these machines are for the most part concentrated at two points, the dam and the quarry, still it is noteworthy that one derrick is being operated by air fully three miles away from the compressors, and the air pressure at this derrick is practically the same as at the compressors.

These 80 machines work the compressors to about two-thirds their capacity, but a few months ago when some 40 Rand drills were in operation the compressors were worked almost up to their full capacity. At no time, however, have there been many more independent machines in operation than at present.

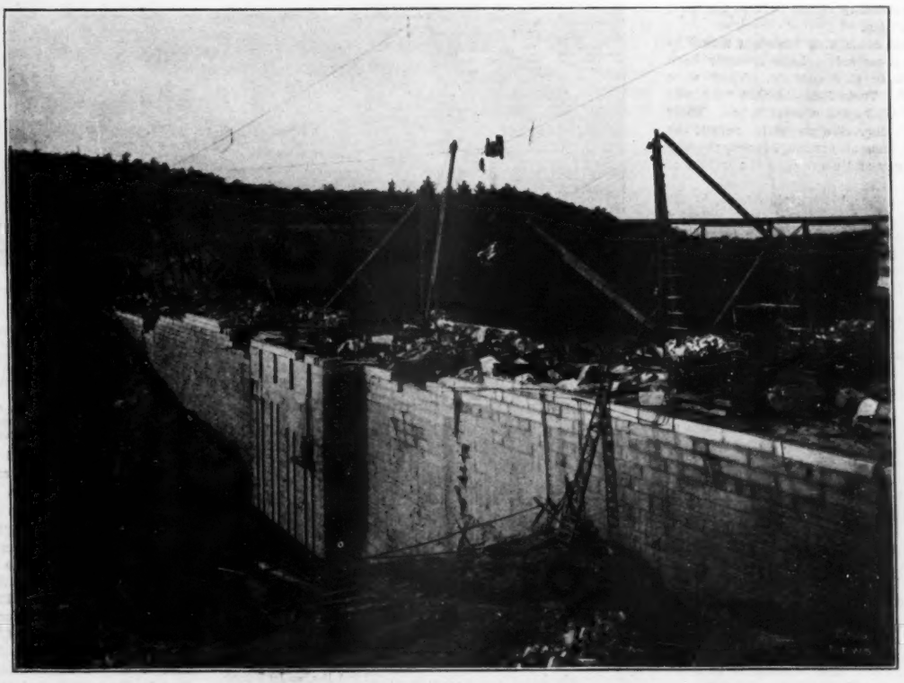
In the quarry, Fig. 4, the rock is loaded into skips which are picked up by air-operated derricks and placed upon flat cars, where men with hose wash all dirt off the stones. The cars are hauled over a standard gage track to the dam, where the cableway lifts the loaded skips and delivers them directly to the derricks on the dam, so that there is no manual rehandling of the stone from the time it is loaded into skips until it reaches its place in the dam.

The stone, which is a granite, breaks out irregularly and in massive blocks, as is well shown by the face in Fig. 5, where a 3¼-in. Rand drill is seen operating under difficulties. Holes are often 24 ft. deep, and are 3 ins. diam. at top and 1¾ ins. at bottom. Including delays involved in setting up the drills in difficult positions, two 24-ft. holes are regarded as a fair day's work for a drill in this granite. Only a small amount of the face stone for the dam is taken from the quarry. For splitting or squaring up large, irregular blocks the contractors have found pneumatic plug drills especially effective. Fig. 6 shows one of the Kotten pneumatic plug drills at work. This drill does not have an automatic rotating device, but the bit is turned with a wrench in the right hand of the operator. By virtue of turning the bit thus by hand, the drill mechanism is very simple, and the drill is certainly effective, as 6 holes, ⅞-diam. × 3 ins. deep, are readily drilled in 9 mins.

A number of large stone surfacing machines are also operated with compressed air, but we reserve a description of their work for another issue.

Not only are all the forges of the blacksmith shop run with compressed air, but, as shown in Fig. 7, a large trip hammer is operated with the same power.

We have indicated briefly the many uses to which compressed air may be put on contract work of this character, but it should not be forgotten that not the least of its advantages over steam is the fact that licensed engineers are not required to operate an engine driven with compressed air. The contractors lay particular stress upon the ability to quickly train a man to run an



UP-STREAM FACE OF THE WACHUSETT DAM, SHOWING PROGRESS OF CONSTRUCTION.

engine where air is used, and the consequent freedom from the dictates of unions. Moreover, to cart the coal to a large number of separate engines would in itself be an item of great cost in the aggregate on work so widely scattered as this. Then, too, to fire up in the morning and to draw the fires at night involves not only a loss of fuel, but longer hours for the engineman, all of which is done away with where compressed air is used.

The economy in fuel that results from generating power by a few large units at a central plant is a fact universally recognized by engineers, but not so often recognized by contractors, or if recognized, is not often used to advantage as in the plant above described. One of the reasons that in the past has led contractors to hesitate to install large central power plants has been the fear of breakdowns that would tie up the whole work. But in so reasoning the perfection of modern machinery is lost sight of. There is a good bit of wisdom in "Pudden' Head Wilson's" philosophy, where he says:

> Some say, "Don't put all your eggs into one basket," but I would say "Put all your eggs into one basket—and watch that basket."

This maxim holds as true of investments in machinery as of investments in stock.

For facts and figures and for courtesy to our representative in examining this plant we are indebted to: Mr. Thomas F. Richardson, Engineer, Dam and Aqueduct Dept., Metropolitan Water and Sewerage Board; to Winston Co. & Locher, Contractors for Wachusett Dam, Clinton, Mass., and to the Rand Drill Co., 128 Broadway, New York.

NON-CORROSIVE NICKEL-STEEL BOILER TUBES.*

By Albert Ladd Colby,† M. Am. Soc. M. E.

During the past two years great prominence has been given to the study of the marine boiler by the navies of the world. Many naval experts have thus been convinced that the question of the durability of the tube is the most important favor of the problem.

Boiler tubes made of steel containing sufficient nickel to make them practically non-corrosive, have recently been successfully manufactured in this country. They were first made abroad in 1898. Tests indicate that they will last 2½ times as long as mild carbon steel tubes. Their increased strength and non-corrosive properties permit the adoption of lighter gages than at present in use, thereby increasing steaming efficiency and decreasing the weight of the boiler installation.

As our navy and merchant marine will doubtless, in the near future, give these American nickel-steel tubes a practical trial, the writer accepted an invitation to present a paper on this promising improvement in the modern marine boiler.

FOREIGN MANUFACTURE AND APPLICATIONS.

In France the manufacture of high nickel-steel tubes, in a commercial way, began in 1898. Since then, at one tube works, some 160 tons of finished tubes have been made, using a steel containing 23% to 25% of nickel. In September, 1901, the French navy put under trial some five tons of these tubes of different sizes. About this time they also purchased some high nickel-steel tubes from another French tube works. It is reported that so far the tests of these tubes are satisfactory, but that no details will be furnished until the trial is completed.

The German navy also have high nickel-steel tubes of German manufacture under trial. In 1899 one German tube works delivered a lot of 25% nickel-steel tubes to the Yarrow Co., Limited, Isle of Dogs, London. Mr. Yarrow's tests of these tubes he made the subject of a paper before the Institute of Naval Architects.‡

The British Admiralty, in December, 1902, had not yet made any practical trial of high nickel-steel boiler tubes. They have made some laboratory experiments on the same make of German 25% nickel-steel tube, as tested by Mr. Yarrow, and the results of their tests agreed with Mr. Yarrow's statements, which will be referred to later.

AMERICAN METHOD OF MANUFACTURE.

In France, at the tube works where most of the nickel-steel boiler tubes have so far been made, the Ehrhardt process of punching a square billet is used. After the first step, however, the number of operations is very much greater than when making the ordinary low carbon steel seamless tube, and frequent "annealing" of the nickel steel, especially during the gradual reductions by cold drawing, has been found necessary. The manufacturing cost, over and above the increased cost of the 23% to 25% nickel-steel billets, is therefore excessive. The writer has just been advised that another French tube company has recently succeeded, by the use of improved machinery, in producing experimentally a few nickel-steel boiler tubes, with a fewer number of reductions than above described. These experimental tubes were made from a 26% nickel-steel.

The German 25% nickel-steel boiler tubes, tested by A. F. Yarrow in 1899, were made by the cupping process from disks cut from rolled plates. This is a more expensive operation than the processes which start by punching or piercing a solid square or round rolled billet.

In Great Britain, as far as could be learned, no tube company has as yet put a high nickel-steel boiler tube on the market, although a few have been made for experimental purposes.

As to American practice it will be gratifying to the members of this society to learn that although the first high nickel-steel boiler tube made in America was finished at Shelby, O., only in February last, that since then the difficulties of their manufacture have been so thoroughly overcome that the 30% nickel-steel seamless cold-drawn marine boiler tubes, now a commercial proposition, are made in practically the same number of operations and with but a slightly greater percentage of discard than customary in the manufacture of ordinary seamless tubes, and furthermore that the finished 30% nickel-steel tube will stand all the manipulating tests contained in the specifications of the Bureau of Steam Engineering, Navy Department, for the acceptance of the carbon-steel seamless cold-drawn marine boiler tubes now in use. In addition the nickel-steel tubes have a much greater tensile strength.

*From a paper read at the Eleventh Annual Meeting of the Society of Naval Architects and Marine Engineers.

†Assistant to President, Orford Copper Co., 43 Exchange Place, New York City.

‡A. F. Yarrow, "Some Experiments having Reference to the Durability of Water-Tube Boilers." Trans. Inst. Naval Architects, Vol. 41, July, 1899, pp. 333-346.

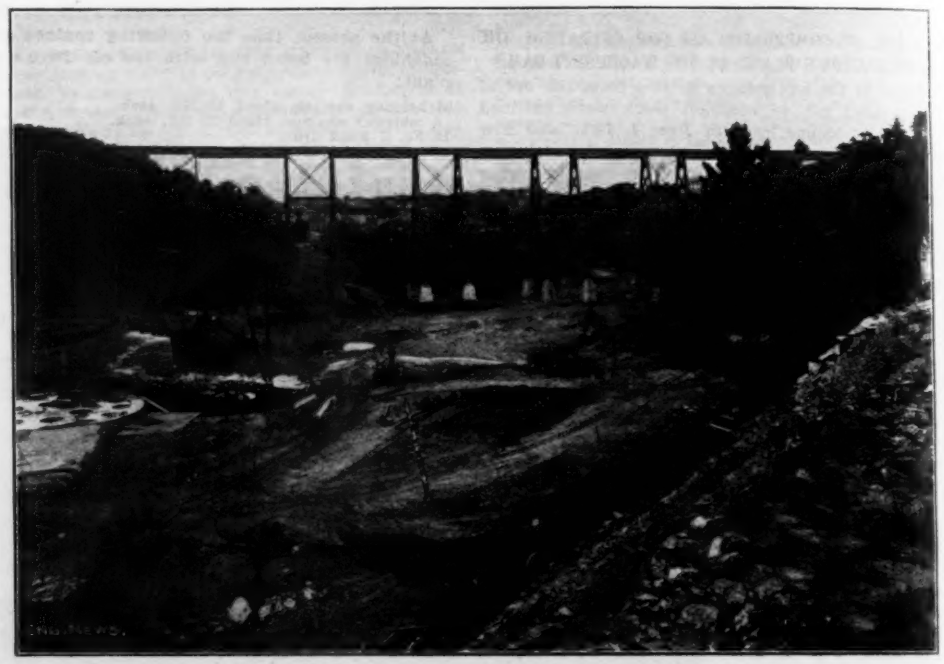


FIG. 2. NEW STEEL VIADUCT BELOW WACHUSETT DAM.

LIGHTER GAGED NICKEL-STEEL TUBES.

The greater tensile strength and elastic limit of the high nickel-steel allows, without danger, the use of a lighter-gaged tube than used in a given boiler when fitting it with mild carbon-steel tubes. This not only partly offsets the higher cost of the nickel-steel tubes per pound, but also increases the steaming efficiency of the boiler. It furthermore decreases the weight of the boiler installation, an important advantage in the case of marine boilers.

The following statement, based on information furnished by the Bureau of Steam Engineering, Navy Department, shows that by substituting the lighter gages, practicable by the adoption of nickel-steel tubing, the following marked saving in the total weight of boiler installation is assured:

For torpedo-boats.. .....23,881 lbs. = 10.7 tons.
For battleships.... ....85,073 lbs. = 38.0 tons.

In one standard type of stationary boilers, there is 11½ lin. ft. of tubes per horse-power. The tubes are 3¼ ins. outside diameter by No. 11* gage. In substituting a nickel-steel tube of this diameter, a No. 13 gage tube could be safely used. The former weighs 4.03 and the latter 3.19 lbs. per ft. In a boiler of 500 HP., the saving in weight by the use of nickel-steel tubes would be 4,830 lbs.

COMPARATIVE COST OF NICKEL-STEEL AND CARBON-STEEL TUBES.

In the following table (not reproduced.—Ed.) the cost of the mild carbon-steel tubes has been assumed at 12 to 15 cts., depending on the thickness of the tube, and at 35 to 40 cts. for the corresponding thickness of nickel-steel tubing. The table shows that the 30% nickel-steel tubes would cost 2.13 times as much as the mild carbon-steel tubes in the case of torpedo-boat destroyers, and 2.43 times as much for battleships.

This extra cost is not prohibitory, considering the fact that the nickel-steel tubes will last 2½ times as long as the carbon-steel tubes, and that when the nickel-steel tubes are finally taken out of the boilers they can be sold for the market price of steel tubing scrap, plus 20 cts. per lb. for the contained nickel. Very recently I have obtained some specific information on this point, which shows that the old tubes could be sold at 6.4 cents per pound.

In the final comparison of net increased cost of the nickel-steel tubes, the increased steaming efficiency due to the lighter-gaged nickel-steel tubes and the saving due to the less frequent retubing of the boilers, as well as the saving in weight of the boiler installation, should be given due consideration.

*The gage numbers for thickness of tubes in this paper refer to the Birmingham wire gage.

PROPERTIES OF HIGH NICKEL-STEEL TUBES.

(a) CAUSES OF DETERIORATION IN MARINE BOILER TUBES.—The probable causes of the deterioration of marine boiler tubes are summarized by Mr. Yarrow as follows:

1 To the action of acids in the water, due to grease, which, in spite of every precaution, finds its way into the boiler.

2. To the tubes becoming overheated and oxidizing on the outside through contact with hot gases when passing from the furnace to the uptake.

3. To the action of the steam, which, if superheated, decomposes, causing deterioration on the inside of the tubes.

The last two conditions occur when the tubes, from defective circulation, shortness of water, or from the collection of scale, become overheated.

To this summary should be added the composition of the feed-water itself, which exercises a marked influence on the corrosion of the tube.

(b) CORROSION AND OXIDATION TESTS WITH ACIDS, HEAT AND SUPERHEATED STEAM.—In order to show the relative deterioration of boiler tubes due to the action of acids in the water, Mr. Yarrow made "corrosion tests" on two mild carbon-steel tubes and two 25% nickel-steel tubes. The four tubes were immersed in 33% hydrochloric acid for 22 1-5 days, and the loss in weight at stated periods determined as shown in Table I.

Mr. Yarrow states that the average loss of weight in the mild carbon-steel tube was, therefore, 16½ times greater than in the nickel-steel tube. He explains that although it may be contended that the relative corrosion of the two steels, when using dilute hydrochloric acid, does not correspond with what it would be with such acids as are present in boilers under working conditions, that it is not unreasonable to suppose that it may serve as a guide.

To determine the comparative oxidizing influence of heat upon the nickel-steel and mild carbon-steel tubes, Mr. Yarrow submitted two pieces of each kind of tube to what he termed the "Fire Test." Two tubes, one of nickel-steel and one of carbon steel, were placed side by side in a small brick furnace, where they were both heated to the same extent and under the same conditions, the heat continuing till the tubes reached a straw color. The experiment was repeated, using two tubes of the same original weight. In both cases the tubes were heated six times, and weighed after cooling and scaling. The total loss in weight of the carbon-steel tubes was 78.37% and 76.06% against 24.47% and 27.66% for the nickel-steel tubes.

To more nearly conform to boiler conditions, two tubes, one of nickel-steel and the other of mild carbon-steel, were placed side by side in a small brick furnace, and maintained at a bright red heat. At one end of each tube steam was supplied at 60 lbs. pressure, it being allowed to issue slowly from the opposite end of each tube, thus insuring the steam being highly superheated.

Mr. Yarrow describes the results of this so-called "Superheated Steam Test" as follows:

Each tube was 1 in. outside diameter by No. 14 L. S. G., by 1 ft. 8⅝ ins. long, and weighed 612.2 grammes. After the experiment had proceeded ten hours it was stopped, as the mild steel tube gave out, steam issuing from the de-

TABLE. I.—CORROSION TEST. EXPERIMENTS TO ASCERTAIN THE EFFECTS OF ACID ON NICKEL-STEEL AND MILD CARBON-STEEL TUBES.

Kind of steel.	Original weight in grms.	Solution used: Two parts of water to one part concentrated hydrochloric acid. Weight in grammes at end of each period of immersion.									Total loss in 533 hours, or 22 days 5 hours.	
		21 hrs.	64 hrs.	44 hrs.	92 hrs.	168 hrs.	72 hrs.	24 hrs.	24 hrs.	24 hrs.	Total hours.	in grms.	in percent.
Nickel ...	190	190	189	189	188	186	186	185	185	185	533	5	2.63
Carbon ..	186	184	173	166	140	101	98	94	91	88	533	98	52.68
Nickel ...	188	188	187	187	186	183	182	181	181	181	533	7	3.72
Carbon ..	188	187	173	162	137	112	95	92	90	88	533	100	53.19

fective place. The loss in weight of the nickel tube was 12.7 grammes, and of the carbon tube 85.2 grammes. Deterioration in this case was due partly to the action of the steam inside of the tube and partly to that of the gases outside.

The loss of weight of a boiler tube from deterioration at the commencement of its life being much less rapid than towards the end of its life, therefore the loss of weight cannot be considered as a quantitative guide for durability, and we continued the superheated steam test as follows: After the mild steel tube had burnt through and allowed the steam to escape, we replaced ot by another similar mild steel tube, corresponding to what would be done in retubing a boiler. The experiment was then continued, and it was found this second mild steel tube gave way and the steam burst through after eight hours, the nickel-steel tube remaining intact. We then substituted this burnt mild steel tube by a third mild steel tube, and we found that after three hours the nickel-steel tube finally gave out.

Every two hours during these experiments the position of the tubes was changed about, not only end for end, but side for side, so as to insure that both tubes were subjected to the same conditions.

It will be seen from this that the durability of the nickel-steel tube corresponded to 21 hours, and the mean durability of the first two mild steel tubes to 9 hours. I think, therefore, there is a reasonable probability that from this cause of deterioration a boiler would require to be retubed 2 1-3 times as often with mild steel tubes as it would with nickel-steel tubes.

(c) TENSILE STRENGTH.—Besides the much greater resistance to corrosion offered by the high nickel-steel tubes, their greater tensile strength and elastic limit is a marked advantage over the seamless mild carbon-steel tubes now in use. This increased strength is furthermore not accompanied by any detrimental reduction in the percentage of elongation, for the nickel-steel tubes show no evidence whatever of brittleness.

Another advantage of the high nickel-steel is that any lengthening of the tube, due to expansion in service, is distributed over its entire length, whereas the soft carbon-steel, as shown by its high percentage of contraction of area, generally elongates locally.

The physical properties of the soft carbon-steel tubes and the high nickel-steel tubes are compared in Table II. The tensile strength and elastic limit of the nickel-steel tube can be varied between wide limits, but in no case are the figures as low as in mild carbon-steel tubes. The tensile strength is somewhat affected by the percentage of nickel present within a range of 23% to 30%, and the elastic limit can be raised by the introduction into the steel of small percentages of chromium. Both of these values are also influenced by the method used in "annealing" the finished tubes.

TABLE II.—Average Physical Properties of Carbon-Steel and Nickel-Steel Tubes.

Properties.	Low carbon-steel tubes.	High nickel-steel tubes.
Tensile strength, lbs. per sq. in.	50,000-55,000	85,000-95,000
Elastic limit, lbs. per sq. in.	30,000-35,000	40,000-45,000
Elongation in 8 ins.	20.00-30.00%	20.00-30.00%

(d) MECHANICAL PROPERTIES.—As might be inferred from the higher tensile strength of the nickel-steel, it is more difficult to draw down into tubes and is considerably tougher in working than mild carbon-steel tubes. Mr. Yarrow reports that he found the German 25% nickel-steel tubes "considerably tougher in working than mild steel; it involved more labor and caused greater wear and tear on the tools employed in expanding and bell-mouthing."

An American maker of stationary boilers to whom a shipment of Shelby 4-in. No. 10 gage 30% nickel-steel tubes was recently made, wrote as follows:

Each of the 81 tubes was perfect, so far as we could see, and no defects developed in working. In expanding the tubes it was necessary to use considerably more care than with mild steel or charcoal iron tubes. Two or three of the sections of nine tubes each were expanded by hand with considerable difficulty; the remainder we expanded by machine and found the work to go better. Owing to the constant rotation of the expander, the pin could be driven in without a tendency to force the roller out, as is the case when the expanding is done by hand.

The mechanical tests made by Mr. Yarrow on 25% nickel-steel tubing give conclusive evidence of the ductility of the steel. This ductility is not impaired by sudden changes of temperature, as he flattened tubes and bent them double after being heated to dull red and plunged into cold water 24 times in succession.

The tests of the 30% nickel-steel tubes manufactured last spring by the Shelby Steel Tube Co. also prove that there need be no fear of brittleness in high nickel-steel tubes, for the steel has stood all the manipulating tests required in the specification of the Bureau of Steam Engineering, Navy Department, for the acceptance of the carbon-steel seamless cold-drawn marine boiler tubes. The text of the portion of the current specification describing these tests is as follows:

Paragraph 4. Tubes which are found satisfactory with respect to their surface, weight and gage will be divided into lots of 100, and two tubes from each lot will be subjected to the following tests:

(a) A piece 3 ins. long, cut from the first tube, must stand being flattened by hammering until the sides are brought parallel with a curve on the inside at the ends not greater than three times the thickness of the metal without showing cracks or flaws, the bend at one side being in the weld, if any.

(b) The end of the second tube must stand being expanded cold to 1 1-6 times its original diameter by driving into it a pin having a taper of 1½ ins. to a foot without showing cracks or flaws. Instead of test (b), at the option of the contractor, an equivalent substitute test may be made as follows: Turn a flange all around the end of the tube, and of a width equal to 15% of the diameter of the tube, all the work to be done cold. If only one of the tubes so tested fails, that tube will be rejected, and the inspector will select two other tubes from the same lot and subject both to the same test as the one that failed, and both of these tubes must be found satisfactory in order that the lot may be passed. The failure to pass satisfactorily either of the tests marked (a) and (b) will reject the lot which they represent.

(e) CONTRACTION AND EXPANSION.—It is well known that soft carbon-steel plates and tubes, when frequently heated and cooled, become permanently reduced in length, and this fact is borne in mind in boiler designs. Mr. Yarrow's experiments indicate a slight difference in this regard between nickel-steel and soft carbon-steel tubes.

There is also a difference in the coefficient of expansion of the two steels. Mr. Yarrow's experiments indicated that 25% nickel-steel tube when heated to dull red expanded to a greater extent than the mild carbon-steel tube. From C. E. Guillaume's careful determinations of the coefficients of expansion of different nickel-steels, it appears that had Mr. Yarrow experimented with a 30% nickel-steel tube, he would have found a somewhat less expansion than with the carbon-steel tube.

Although this difference in expansion would be much less under usual boiler conditions, where the maximum preasure is 250 lbs., corresponding to a temperature of 208° C. (406° F.), I nevertheless agree with Mr. Yarrow that there is a possible risk in placing nickel-steel tubes only in those parts of a boiler where deterioration proceeds most rapidly and using mild carbon-steel tubes in the balance of the boiler. In view of Mr. Yarrow's conclusions that the nickel-steel tube has at least twice the life of a mild carbon-steel tube, an experimental trial of both steels in the same boiler would probably not determine the actual efficiency of the nickel-steel tube, as before they needed replacing some of the mild steel tubes would fail and put the boiler out of commission.

A proper comparison, and ultimately the most economical, would be when repairing the boilers of a torpedo-boat, cruiser or battleship, to retube one entire boiler with 30% nickel-steel tubes and another similar boiler with new mild carbon-steel tubes.

(f) HOMOGENEITY.—No alloy unless homogeneous can give satisfaction in service. In this particular nickel-steel leaves nothing to be desired. Nickel readily mixes with the iron during melting, and, what is of equal importance, does not segregate during the solidification of the nickel-steel ingots. This is natural, as the atomic volume, atomic weight and other properties of nickel are very similar to those of iron. The writer's experience, as well as that of others who have made a special study of nickel-steels, is that the presence of nickel in steel tends to check the segregation of the other elements present, such as sulphur, phosphorus, carbon, manganese and silicon.

APPLICATIONS OF NICKEL-STEEL TUBES OTHER THAN FOR MARINE BOILERS.

Although foreign to the subject of this paper, a short reference to the application of nickel-steel tubes other than for marine boilers seems warranted, as but little has been published on the subject.

CONDENSERS.—The French navy began a trial of about 1,800 30% nickel-steel condenser tubes in the latter part of 1902. These tubes were of .630 to .700-in. (16 to 18 mm.) diameters and 11 ft. 5 ins. long. They are to replace the tin-coated brass tube now used, which has failed where the two ends of the tube enter the two drums, and which is made of bronze.

American 30% nickel-steel condenser tubes are offered in the standard size of ⅝-in. outside diameter by No. 18 gage. As the price compares favorably with that of the copper-zinc-tin condenser tube now in use, a comparative trial is about to be made to ascertain whether they will last longer than the copper alloy.

SUPERHEATERS.—The Royal Shipbuilding & Engineering Co., of Flushing, Holland, are using to some extent a German make of 28% nickel-steel superheater tube, 1⅛ ins. diameter and ⅛-in. thick. The high price (25 marks per meter = $1.81 per ft., or about 98 cts. per lb.), prevents its more extended use for this purpose, for which they find it is particularly applicable. A tensile specimen

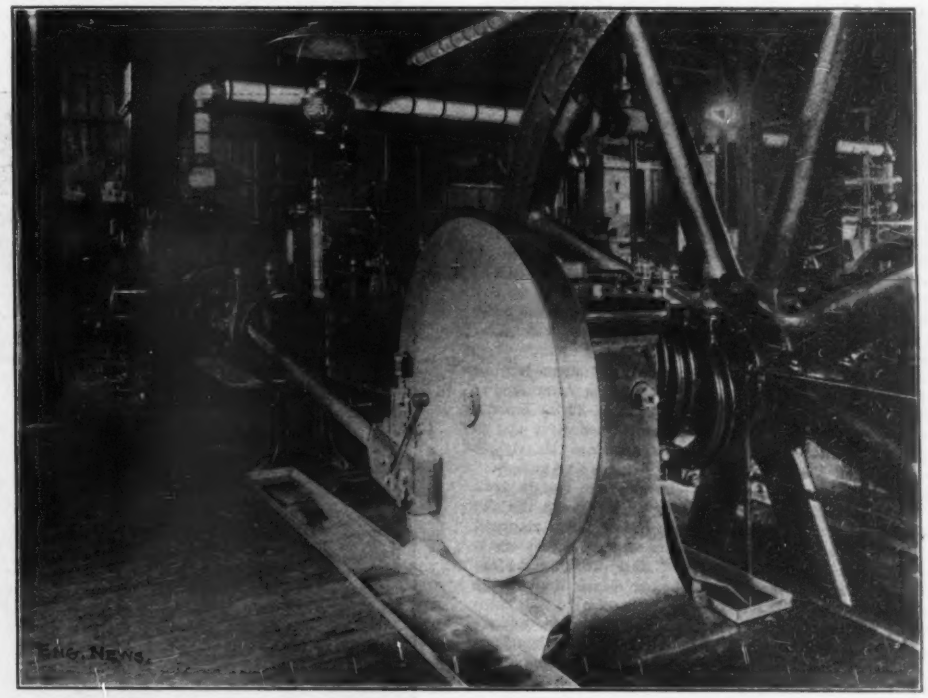


FIG. 3. INTERIOR OF POWER HOUSE, SHOWING TWO 500-HP. AIR COMPRESSORS MADE BY RAND DRILL CO., OF NEW YORK.

cut from a piece of this tube showed the following properties:

Tensile strength .....86,755 lbs. per sq. in.
Elastic limit..... ....48,543 lbs. per sq. in.
Elongation in 8 ins.....27.50%

American 30% nickel-steel superheater tubes are now on the market at a much lower price than above quoted.

The resistance of nickel-steel tubes to the combined action of superheated steam and hot gases described in

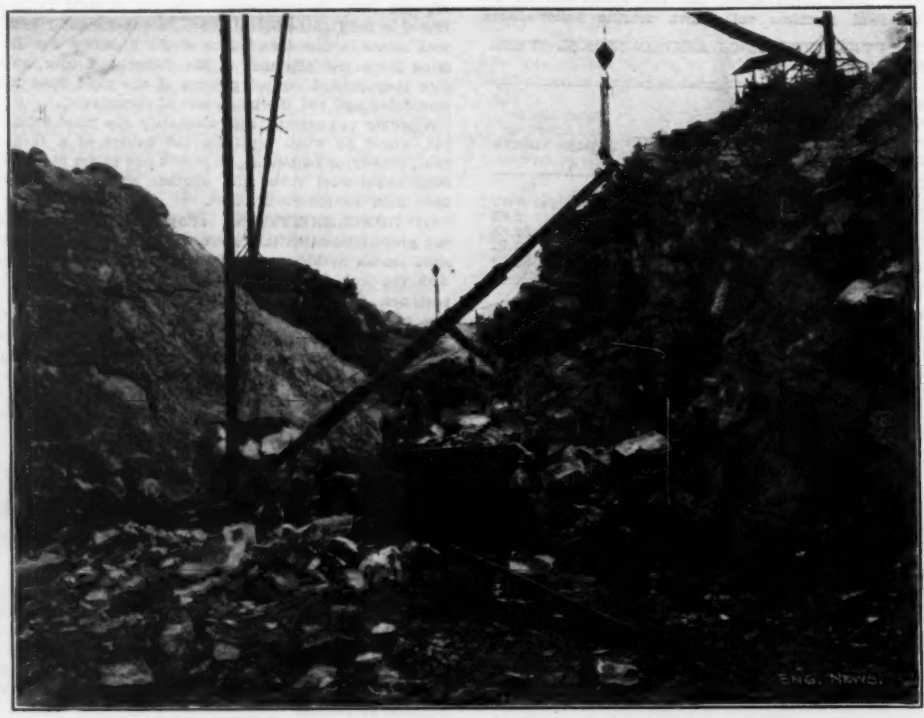


FIG. 4. QUARRY NEAR WACHUSETT DAM, SHOWING SKIPS ON CAR AND AIR-OPERATED DERRICKS.

Yarrow's tests, quoted above, under "Corrosion and Oxidation," proves that a 30% nickel-steel tube will give long service in superheaters.

STATIONARY BOILERS.—A stationary boiler has recently been fitted with Shelby 30% nickel-steel tubes, and will be subjected to a severe service to determine the life of the tubes. There are nine sections in the boiler of nine tubes each, the tube being 4 ins. outside diameter by No. 10 gage by 18 ft. long.

AUTOMOBILE BOILERS.—In France 23% to 25% nickel-steel tubing is used in the tubular boilers of the steam automobiles of the Gardner-Serpollet type. Each coiled section is made from one long piece of the nickel-steel tubing bent into complicated shapes. By a special method of heat treatment the high nickel-steel tubing stands this bending without any danger of cracking or any reduction in the strength of the bent portions of the tube. At one French works some fifty of these nickel-steel automobile coiled sections are made per day.

One of the prominent American makers of steam touring cars has now under trial some coils made from Shelby 30% nickel-steel tubes. The tubing is 17-32-in. outside diameter by No. 15 gage. So far the comparative test is satisfactory, but some time must elapse before the relative superiority of the nickel-steel tube can be determined.

LOCOMOTIVE SAFE-ENDS.—Locomotive boilers leak at the ends of the tubes where they pass through the flue sheets. When this occurs the locomotive must be returned to the shop and the tubes "expanded." This leakage is due to the compression of the soft steel tubes by the expansion of the flue sheets. The higher elastic limit of the nickel-steel insures buch greater resistance to this permanent deformation of the tube, and to gain this advantage without undue cost a nickel-steel safe-end has been made by welding a piece of nickel-steel tube about 3 ins. long to a piece of soft carbon-steel tube, which later can be welded on to the old boiler tube when repairing a locomotive boiler in the railroad shops. About 1,000 of these 30% nickel-steel safe-ends have been recently delivered to prominent American railways, and the results of this promising application of nickel-stel tubing will be watched with interest.

ARTILLERY WAGONS.—Since 1898 one French tube works has delivered to the French Artillery some 50 tons of 12% nickel-steel tubes, mostly of 1.378-in. to 1.811-in. (36 to 46 mm.) diameters. These have been used in various parts of the new French field artillery wagons, such as axles, brake beems and carriage transoms. That the desirable reduction in weight secured by this use of tubing is not accompanied by a loss in strength or stiffness is evidenced by the following remarkable physical properties obtained on tests cut from a hollow artillery wagon axle, exhibited at the Paris Exposition of 1900 and made from a piece of this 12% nickel-steel tubing.

Tensile strength..248,904 lbs. per sq. in.(175 kilos per mm²)
Elastic limit.....170,676 lbs. per sq. in.(120 kilos per mm²)
Elongation.... ..11%

This 12% nickel-steel in various sized tubes, of thicknesses usually varying from .079-in. to .118-in. (2 to 3 mm.), has been made for the frames and some other parts of some some of the French makes of automobiles and for the frames and handle-bars of bicycles. Two French tube works are regularly engaged in the manufacture of this 12% nickel-steel tubing. One of these works exhibited at Paris, in 1900, two grades of this tubing, for each of which the following range in physical qualities were claimed:

	Tensile strength. Lbs. per sq. in.	Tensile strength. Kilos per mm².	Elongation.
Softest grade. . .	135,119-142,231	95-100	18.00%
Hardest grade. . .	248,904-256,015	175-180	4.00%

BICYCLES.—The application of 5% nickel-steel tubing in the manufacture of bicycles made by the Pope Bicycle Co. in 1896, when the bicycle fad was at its height, is too well known to need more than mere mention.

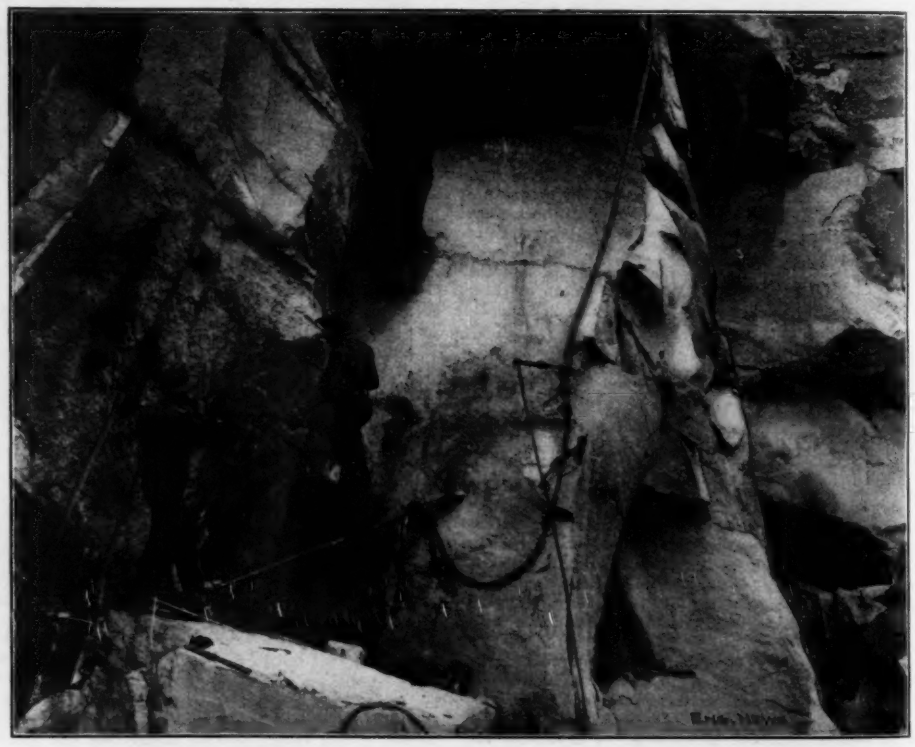


FIG. 5. A RAND DRILL OPERATING UNDER DIFFICULTIES.

THE PROGRESS OF SHIPBUILDING AND STEAM NAVIGATION.*

By Sir William White,† K.C.B., F.R.S., President of the Institution of Civil Engineers.

In the first charter of the Institution, granted in 1828, amongst the many branches of civil engineering which the Society was intended to promote, mention is made of "the art of navigation by artificial power for the purpose of commerce." This was 16 years after the "Comet" had commenced her service on the Clyde, and seven years after the first iron paddle-steamer, the "Aaron Manby," had crossed the Channel for service on the Seine.

Throughout its subsequent history the Institution has continued to manifest keen interest in the construction and propulsion of ships. Its membership has included eminent shipbuilders and marine engineers. It is, therefore, the more notable that during the 85 years of its existence no naval architect or shipbuilder has occupied the Presidential Chair.

It is my purpose in this address to attempt a review of the progress of shipbuilding and engineering during the 44 years that have elapsed since I commenced my apprenticeship as a lad of fourteen. The story will deal chiefly with things I have personally seen or known, and it is worth telling; but so wide is the range and so eventful the narrative, that it is impossible to do it justice.

Before dealing with these questions, however, there are some matters of general interest, although of a "domestic" character, to which brief reference must be made.

PRESENT POSITION OF THE INSTITUTION.

After 85 years of strenuous existence the Institution maintains its vitality unimpaired. Judged by the common standard of the length of its roll the Institution flourishes. Greater weight attaches, however, to the individual qualification essential to membership than to mere numbers; and measured by that standard, much progress has been made in recent years. The introduction of a system of qualifying examinations for admission of students and associate members is comparatively recent. The system has been gradually developed during the last fourteen years, and it has received constant thought and attention from the council and officers. It is desired that young men entering the profession shall be equipped with a sound general education before they commence their special scientific and practical training. Moreover, the council insist upon the necessity for practical qualifications as well as for theoretical attainments, the former being proved by a period of actual work under experienced engineers, the latter being tested by examination.

The general position may be summarized in the statement that by this system the Institution is inculcating

*Condensed from the Presidential Address delivered before the Institution of Civil Engineers.

†Late Director of Naval Construction of the British Admiralty.

in a student class close upon 1,000 strong, the principles it has evolved with regard to engineering training. Engineering claims to be one of the learned professions, and we offer the best proof possible in support of the claim. No greater evidence of our interest in the welfare of the students and the future of engineering could have been given than by the establishment of these examinations.

In the past the Institution stood almost without a rival, dominating the entire field of engineering. As engineering has been developed it has specialized, and societies have been established to deal with particular branches or local needs. The founders of the Institution could not possibly have foreseen subsequent developments, but their scheme was so broadly conceived as to embrace all branches of civil engineering now no less than it did at the beginning. The Institution welcomes the development of local and sectional societies, recognizing fully that there is room for them without loss to itself or interference with its work. The correlation and interdependence of all branches of engineering are recognized as being absolutely necessary, and the more so as specialization proceeds. The need for a great central institution in which all civil engineers can associate and confer becomes greater, and loyalty to the parent Institution is probably greater now than under earlier and simpler circumstances. We need have no fear for the future so long as the comprehensiveness and catholicity which mark our methods are maintained.

The question of education and training for engineers is now receiving an unusual amount of attention, for good and sufficient reasons which need not be specified. At the recent Conference a valuable discussion took place, and at other engineering societies similar discussions have occurred. Had it not been for my occupancy of this chair, I should now have been in the United States with the Mosely Commission gaining detailed information. All that I will now say is, that there is undoubtedly a need for inquiry by representative engineers into existing and possible courses of instruction. A request that this Institution would take the lead in constituting a representative committee to conduct this inquiry is now under consideration by the Council.

VISIT TO AMERICA IN 1904.

An invitation to visit American was received some months ago from the American Society of Civil Engineers, who wished to return in New York the courtesies it has been the privilege of this Institution to show to American engineers in London on two recent occasions. Steps were taken by the Council to ascertain the views of members, as such a visit was unprecedented in the history of the Institution, and the replies were of a character which induced the Council to accept the very cordial invitation that had been received. The time will be fixed so as to enable those of the party who desire to do so to take part in the International Engineering Congress which is to be held at St. Louis early in October. Details for the visit have still to be worked out, and this will form one of the occupations of the session.

ENGINEERING STANDARDS COMMITTEE.

The work of this committee proceeds on the lines originally laid down, but extensions of the scheme have naturally taken place, and new sub-committees appointed to deal with special subjects. Reports have been presented and published dealing with British standard sections for bars of various forms, with tram-rails, and with locomotive engines for India. It is gratifying to know that, besides the approval and financial assistance of the scheme by the British Government, the Indian Office has recently made a special grant of £1,000 in recognition of the value of the work done on its behalf. There is reason to hope that, as the scope and character of the undertaking are better understood, and the beneficial results of its operation made apparent, more adequate assistance from the public funds will be available, as the efficiency and commercial success of so many branches of manufacture must be greatly promoted, and the members of the committee are giving gratuitous service to the State to an extent representing very large contributions from the engineering profession.

While my sympathy with the work of standardizing is thorough, and for 25 years in my own practice I have adopted it, I cannot leave the subject without recording the opinion that there is a danger of unwise advocacy and undue extension of such a method. Some advocates of standardizing—not engineers—are so enamored with the idea of advantage resulting from repetition of patterns and identity of forms, that they are often in danger of pushing the process to absurd and injurious lengths. Interchangeability is desirable within limits, so long as it is practically effective; but when it has little or no practical value in service, and involves greatly increased first cost and delays in manufacture, then standardization is not to be commended. Nor should it be ever permitted to kill down continuous improvement, paralyze invention, or prevent completion in design tending to advance. These may seem truisms, but the caution is not given without adequate reason. So long as standardization remains in the hands and under the control of such a representative committee of practical engineers and manufacturers, the dangers mentioned need not be feared. It is the amateur who, in concentrating attention on one aspect of a great subject, loses sight of others and retains no sense of proportion, who is to be feared, when he has the power to influence action.

SHIPBUILDING IN 1859-60.

In March, 1859, before the "Warrior" was ordered, my association with shipbuilding began. The Royal Dockyards were then crowded with men, and working overtime to hasten the steam reconstruction. My first employment was on a line-of-battle ship, built as a sailing three-decker many years before, which was undergoing conversion into a screw two-decker.

The screw three-deckers built in 1855-59 were splendid specimens of what could be accomplished with wood as the principal material for construction, and embodied not merely the accumulated experience of centuries in hulls, rigging, equipment and armament, but that of nearly half a century of marine engineering. The "Victoria," launched in November, 1859, was 260 ft. long, 60 ft. broad, had a mean draft of 26 ft. 3 ins., and an extreme draft of nearly 28 ft. Her displacement was about 7,000 tons, her engines developed 4,200 HP., with a corresponding speed of about 12¼ knots. She had a full sailing equipment, the sails aggregating 31,000 sq. ft. in area. The funnel could be lowered, and the screw could be lifted out of water when the ship was under sail. Her armament consisted of 121 guns, mounted on three gun-decks and an upper deck. All were smooth bores, firing spherical cast-iron projectiles; one was an 8-in. 68-pounder pivot-gun, weighing 95 cwt.; 62 were 8-in. shell-guns, weighing 65 cwt., and firing 56-lb. projectiles; and 58 were 32-pounders weighing 56 cwt. All except the pivot-gun were mounted on wooden-truck carriages. How small had been the advance in naval gunnery will be seen from the statement that in the ships of Queen Elizabeth's reign there were guns of 8-in. to 8½-in. caliber, discharging projectiles weighing 60 lbs. to 66 lbs. There were, of course, many features in the later weapons, giving them superiority over the earlier, and the 8-in. shell-gun indicated a new departure. But in essentials of guns, mountings and projectiles, there had been no great change in nearly 300 years. The cost of the "Victoria" was £217,000, nearly one-third of that amount being expended on machinery.

It will be interesting to add a few facts as to the largest representative merchant ships of 1859-60. With the advent of iron hulls and steam power, came rapid growth in dimensions of merchant vessels, but they were still inferior to the largest warships in displacement.

The finest ship in the Cunard fleet in 1859 was the iron paddle-wheel steamer "Persia." By the courtesy of the company I have been able to add to the particulars for this notable vessel appearing in various publications. She was 360 ft. long, 45 ft. broad, and 31.5 ft. molded depth. Her gross register tonnage was 3,300 tons. Her deep load draft leaving port was about 23 ft., with a corresponding displacement of about 6,000 tons; if laden to 24 ft., it would have been about 6,400 tons. Her engines developed 4,000 HP., and gave her a sea speed of nearly 13 knots; the daily consumption of coal was 150 tons, and she carried 1,000 tons in her bunkers. Her dead-weight capacity for cargo was 1,100 tons, and she had cabin accommodation for 180 passengers. This was the finest trans-Atlantic steamer of that date. Her fastest passages took nine to ten days. She was heavily rigged, and the quicker passages were, no doubt, made with favorable winds.

The iron screw-steamer "Ceylon," of the Peninsular & Oriental Company, was in 1859 the finest vessel on the Alexandria mail service; she was 306 ft. long, 41 ft. broad, and nearly 28 ft. deep; 2,000 gross register tonnage; load draft about 20 ft. Her engine developed about 1,500 HP., and her sea-speed was 12½ knots to 13 knots; she burnt about 60 tons of coal per day, and carried 11 to 12 days' supply.

Turning to the Cape service, in 1860 the mails were

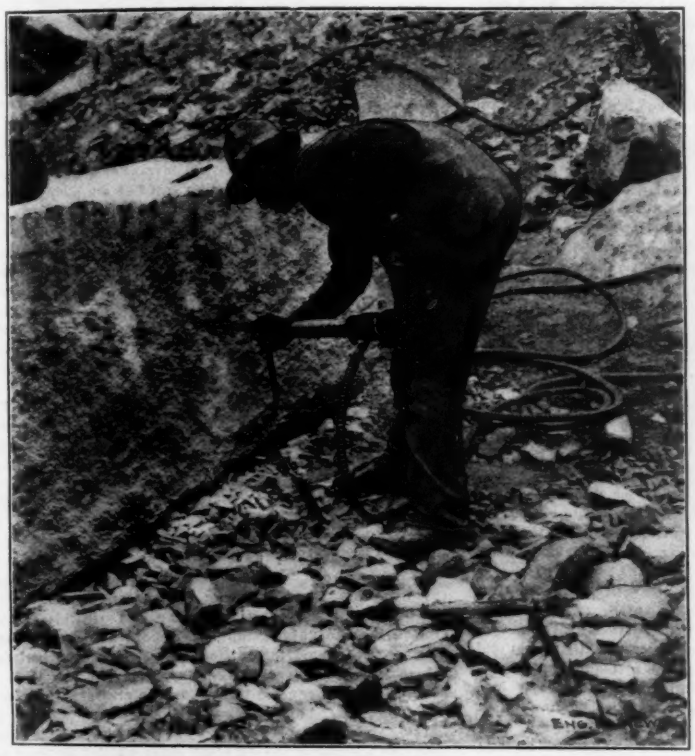
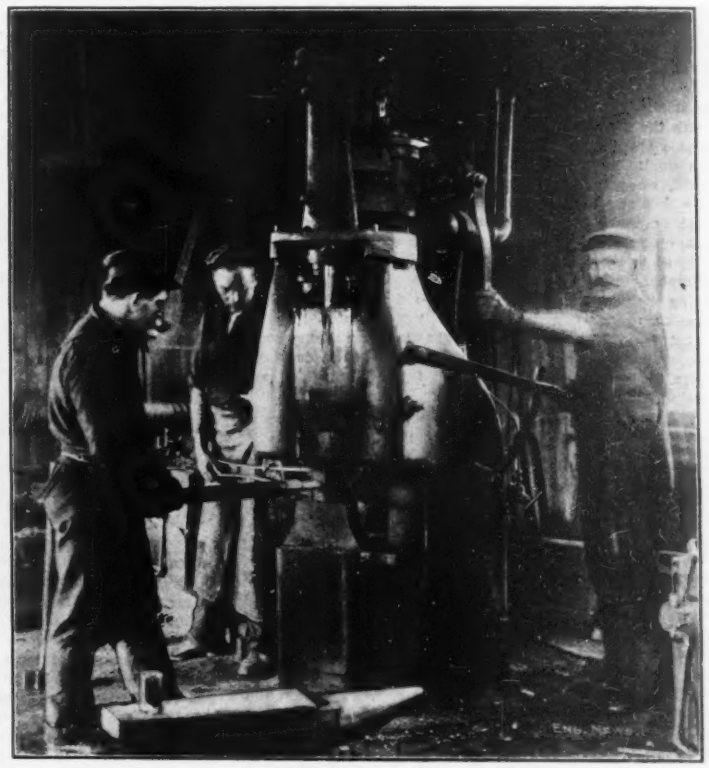


FIG. 6. PNEUMATIC PLUG DRILL, MADE BY H. KOTTEN, 120 LIBERTY ST., NEW YORK.



F.G. 7. TRIP HAMMER OPERATED WITH COMPRESSED AIR.

carried in iron screw-steamers about 180 ft. in length, 25 ft. broad, and 17 ft. deep having a mean draft of 14 ft. The gross tonnage was 550 tons; horse-power, about 300 to 350; speed, 8½ knots to 9 knots.

The Royal Mail Co. were carrying mails and passengers to the West Indies in vessels of 12½ knots to 13½ knots sea-speed. The "Atrato" was their largest vessel in 1860. She was 336 ft. long, 41 ft. broad, and 33.7 ft. deep, over 3,100 tons gross, drew about 21 ft. when laden, was propelled by paddle-wheels of 2,500 HP. to 3,000 HP., and had a speed of 13 knots to 13½ knots.

THE "GREAT EASTERN" (1853-90).

These particulars for representative steamships are of interest as illustartions of the progress made from the real commencement of ocean steam navigation in 1838, and as a means of comparison between the largest and swiftest mail steamers of 1859-60 and the largest screw line of battleships of that date. In addition they are of value as an indication of the magnitude of the departure from precedent and experience made by Brunel when he undertook the design of the "Great Eastern." That wonderful ship started on her first cruise on Sept. 7, 1859, and the great engineer died on Sept. 19. Fortunately, there remain in the reports and memoranda included in his published "Life" a fairly complete account of the fundamental ideas on which the design of the vessel was based, the manner in which the dimensions were determined, and the structural features decided.

At the close of the year 1851 he began to study the problem of constructing a vessel capable of carrying coal sufficient for the voyage to Australia and back—that is, the circumnavigation of the world—in association with the accommodation for a large number of passengers and a reasonable amount of cargo. This subject occupied no small share of his time and thought until the end of 1853, when contracts were signed for the construction of the ship and propelling machinery. Brunel sought advice and asistance in all quarters, and frankly acknowledged his obligations, saying to the directors of the company formed to build the ship, "I have not hesitated to consult everybody whose opinions I considered valuable, and to bring the result of their opinions in aid of my own and the manufacturers' experience." But it is clear that all the great features of the design—structure, arrangement of propelling machinery and determination of dimensions—were his own work. He accepted full responsibility, and spared no pains to secure success. He said:

> I never embarked on any one thing to which I have so entirely devoted myself, and to which I have devoted so much time, thought and labor, on the success of which I have staked so much reputation, and to which I have so largely committed myself and those who were disposed to place faith in me.

There is ample evidence that this was no exaggerated view of his action. Personally I have been familiar with the facts for many years; but having recently gone again most carefully through Brunel's notes and reports, my admiration for the remarkable grasp and foresight therein displayed has been greatly increased. In regard to the provision of ample structural strength with a minimum of weight, the increase of safety by water-tight subdivision and cellular double bottom, the design of propelling machinery and boilers, with a view to economy of coal and great endurance for long-distance steaming, the selection of forms and dimensions likely to minimize resistance and favor good behavior at sea, and to other features of the design which need not be specified, Brunel displayed a knowledge of principles such as no other ship-designer of that time seems to have possessed; and in most of these features his intentions were realized. The capital was raised, and in the spring of 1853 the construction of the "Great Eastern" began. After many vicissitudes, she was launched on Jan. 31, 1858, and made her first cruise in September, 1859.

Exception may reasonably be taken now to the wisdom of the fundamental conditions laid down for the design or to the correctness of the estimates of possible earnings. From the technical side, however, interest centers in the fact that Brunel undertook to produce a ship capable of carrying coal sufficient for the voyage to Australia and back, at an average speed of 14 knots, 36 days being allowed for the passage. She was to accommodate 3,000 persons easily, carry a small amount of cargo only on the outward passage, and homeward to bring "any amount that could be collected," cargo taking the place of the coal burnt on the volage out. The great ship was to be equally available for service between England and India if required, carrying coal enough to take her to Calcutta and thence to Trincomalee with 3,000 tons of cargo.

The dimensions ultimately adopted were: Length over all, 693 ft.; length between perpendiculars, 680 ft.; breadth, extreme, of hull, 83 ft.; breadth over paddle boxes, 120 ft.; depth, 58 ft. At the time of the design (1852-3) it must be remembered that the most powerful Cunard steamers were 285 ft. long, of less than 2,500 tons gross and 5,000 tons displacement at deep draft, having 12½ knots sea speed, the engines developing 3,000 HP.; while the "Himalaya," as previously mentioned, was 340 ft. long, 3,400 tons gross, 4,000 tons displacement, with 2,000 HP. and 12 knots speed. The screw two-deck line-of-battle ship "Agamemnon," of the same date, was 230 ft. long, 5,000 tons displacement, and on the measured mile attained 11¼ knots with 2,300 HP.

Under these circumstances it was necessary to subdivide the power, so that the step required of the manufacturers beyond previous experience should be minimized. Brunel decided to associate paddle-wheels with a screw-propeller, and to have about 60% of the total power in the screw-engines. Mr. Scott Russell undertook the construction of the latter and of the hull; Messrs. Boulton and Watt made the paddle-engines. In both cases the task was efficiently performed, and the engines did well throughout the service of the ship.

Brunel thoroughly appreciated the paramount importance of economy in coal consumption on a voyage of such great length. He insisted on 25 lbs. pressure, although leading engineers urged him not to go beyond 15 lbs.; he proposed steam-jacketing (with steam supplied from an auxiliary boiler of higher pressure than the main boilers), superheating and improved jet-condensers, besides other devices for preventing waste of heat. On these heads his notes are of the greatest interest. His estimate was, that a consumption of 200 tons per day would suffice at 14 knots. Taking 7,000 HP. only as the power developed, this means that the rate of coal consumption he anticipated would have been 2⅝ lbs. per I. HP. per hour. The best practice at that time gave 3½ lbs. to 4 lbs. per HP.-hr.; and although many of Brunel's ideas were not carried out in the construction, it is obvious that in this important particular he was much too sanguine. Records of actual consumption are few and somewhat conflicting, but a careful analysis of the figures leads us to the conclusion that at 14 knots the vessel must have burnt at least 350 tons per day, and probably burnt 380 to 400 tons.

She was never tried on the Australian service, and on the Atlantic her voyages were so few, irregular, and marred by accidents, that there was no true test of her capability, nor was she run at the deep departure draft of 30 ft.

It has surprised me to find no trace in Brunel's notes of any contemplated use of twin screws instead of a combination of screw and paddles. He left so few stones unturned in his search for the best that it is singular to find this arrangement unnoticed.

In deciding upon the form and dimensions of the vessel, Brunel took counsel with Scott Russell, and could have found no more competent adviser. Writing in 1857, Scott Russell defined his position thus:

> I designed her lines and constructed the iron hull of the ship, and am responsible for her merits and defects as a piece of naval architecture. Her lines are identical with those of my other ships, which are constructed like this on a principle of my own, which I have systematically carried out during the last twenty years, and which is commonly called the wave principle.

In structure the "Great Eastern" was not merely a marvel, considering the date of her construction, but is still, in my judgment, a most fruitful and suggestive field of study. Here Brunel was greatly influenced by practice in bridge-building. To him a ship had always been a girder, in regard to longitudinal strength, from the time (1840) when he designed the "Great Western." In the "Great Britain" he made many new structural arrangements which proved most successful; and that ship did good service for nearly forty years as a steamer before she was converted into a sailing ship, and subsequently into a hulk in the Falkland Islands. When he began work on the "Great Eastern," he laid down the "principle of construction" that "no material shall be employed on any part except at the place and in the direction and in the proportion in which it is required, and can be usefully employed for the strength of the ship, and none merely for the purpose of facilitating the framing and first construction."

The Menai tubular bridge undoubtedly influenced Brunel greatly in the main features of the structure of the "Great Eastern," and the experiments made by Robert Stephenson and Fairbairn furnished valuable information.

As to strength, the vessel was severely tested during the 32 years she remained afloat. She carried enormous loads of submarine cables, encountered very severe weather, ran on the rocks off Montauk Point, and tore a hole in the outer skin 80 ft. long by 10 ft. broad, but proceeded to New York, her passengers being unaware of the damage done. She was repeatedly beached on a "gridiron" at Milford Haven for repairs; yet throughout this service no signs whatever of structural weakness occurred, and local damage was readily made good.

I have most thoroughly investigated the question of the weight absorbed in the structure of the "Great Eastern," and my conclusion is that it is considerably less than that of steel-built ships of approximately the same dimensions and of the most recent construction. Of course, these vessels are much faster, have more powerful engines, and have superstructures for passenger accommodation towering above the true upper decks which form the upper flanges of the girders. These, and other features I cannot now specify, involve additional weight; and the "Great Eastern" has the advantage of being deeper in relation to her length than the modern ships. After making full allowance for these differences, my conclusion is that the "Great Eastern" was a relatively lighter structure, although at the time she was built only iron plates of very moderate size were available, and the plates used for the outer and inner skins were only ¾-in. thick.

CHANGES IN THE MACHINERY OF STEAM VESSELS.

In 1859 the highest steam pressures used in marine boilers were from 20 lbs. to 25 lbs. per sq. in.; twenty years later 90 lbs. to 100 lbs. had been reached, and the "compound"—double-expansion—type of engine was in general use. Now in the mercantile marine, with the ordinary—water-tank cylindrical—boilers, pressures of 210 lbs. to 220 lbs. are common, and a little less than 270 lbs. has been reached in a few cases. For warships, with water-tube boilers, pressures of 250 lbs. to 300 lbs. have been used for nine years; but in the most recent vessels, in which 20% of the total power is in cylindrical boilers, with the balance in water-tube boilers, the pressure adopted is only 210 lbs. With these high pressures triple or quadruple-expansion engines are associated.

There is a widespread feeling amongst marine engineers that, with cylindrical, or "tank" boilers, it is not desirable to exceed 220 lbs. per sq. in. as the steam pressure; and, although quadruple-expansion engines are favored for the highest pressures used in the mercantile marine, triple-expansion engines are made in much larger numbers. For ships of the Royal Navy triple-expansion engines of the four-cylinder type are used, with two low-pressure cylinders and four cranks; and this is the arrangement adopted in many large-powered merchant steamships. With higher steam pressures than 220 lbs., certain difficulties occur in the pipe joints and other parts liable to leakage of steam.

This rise in pressure and greater expansion have been accomplished by an increased rate of revolution and piston speed. In 1859 for the best types of engines in screw steamers the revolutions did not exceed 50, and the maximum piston speeds were about 400 ft. per minute. In 1881 the averages for merchant steamers were about 60 revolutions, with 470 ft. per minute piston speed; now the corresponding averages are nearly 90 revolutions, and over 650 ft., while many steamers of high speed attain piston speeds of 900 ft. to 1,000 ft. The "Deutschland," at first, is reported to have worked at about 75 revolutions with over 900 ft. piston speed; on her later service the revolutions have risen to over 80 per minute with 1,000 ft. piston speed when developing about 36,000 HP. with twin-screw engines. In warships the rates of revolution are higher and strokes shorter than in merchant ships. In 1881 the revolutions for battleships were about 80, and the piston speeds about 650 ft. to 700 ft. per minute. Now they have been increased to 100 or 110 revolutions, with 850 ft. to 900 ft. piston speed. For swift cruisers of large power, 120 to 140 revolutions and 1,000 ft. of piston speed are now common; smaller cruisers have about 220 revolutions with equal piston speed; destroyers have 350 to 400 revolutions and 1,100 ft. to 1,200 ft. piston speeds.

It need hardly be remarked that these increases in revolutions were associated with a change from horizontal to inverted-vertical cylinder engines. The change was made in merchant ships many years before it was adopted in warships, wherein it was considered important to give increased protection by placing engines and boilers below the water line. When armor came into use this consideration became unimportant, and about 1873 vertical engines were adopted for battleships. For cruisers horizontal engines were used in the Royal Navy up to 1886. I adopted vertical engines in the torpedo cruisers "Panther" and "Leopard," built at Elswick for the Austrian navy in 1884-5, and the results were so satisfactory that the same type was adopted in the "Medea" class, which I designed for the Royal Navy in 1886. Now vertical engines are universally adopted in warships, including the smaller classes.

Remarkable economies of weight in proportion to power developed have accompanied these changes. Taking the contractors' trials for the specified maximum power, it is found that each ton weight of propelling apparatus, in full working order, gave about 6 I. HP. in 1859; whereas in present practice about 9 I. HP. is obtained in battleships with cylindrical boilers, and about 10.5 I. HP. with water-tube boilers. In large cruisers with water-tube boilers, such as the "Drake" class, about 12 HP. per ton is obtained; in thrid-class cruisers with water-tube boilers, having thinner and smaller tubes, about 20 HP.; and in destroyers from 40 HP. to 50 HP. The large cruisers have proved themselves capable of developing about 75% of their maximum power for continuous steaming at sea, which corresponds to 9 HP. per ton; for the small cruisers and destroyers 50% to 60% of the maximum power can be maintained as long as the coal lasts; taking 50%, this gives 10 HP. per ton weight for the cruisers, and over 20 HP. per ton for the destroyers.

Warships differ from merchant ships in one important feature, to which sufficient weight is often not attached. Their ordinary service is performed at low speed, with a very small percentage of their maximum power, and full speed is the exception. Long-distance passage trials are made at intervals, but usually not with more than 60% to 75% of maximum power specified in the contracts for machinery. On the other hand, merchant steamers are designed and engined to steam at full speed, and under fairly uniform conditions of development of power on all their passages. The swiftest of them run between certain terminal ports at regular speeds except as affected by weather and sea. All this favors economy, and to ensure regularity of service it is reasonable that larger margins of weight in proportion to power should be allowed than in

warships. Moreover, in many parts of the machinery of warships sensible increase in first cost is accepted in order to reduce weight, since every possible saving in weight is of advantage. In mercantile practice this policy is not carried so far. There have also been great relative savings in the proportion of weight to power in mercantile steamships. In 1839 the best direct-acting screw engines developed on service 3 HP. to 4 HP. per ton. Now the corresponding development is 6 HP. to 6.5 HP. per ton in swift mail steamers of the highest class, in ordinary cargo steamers 4 HP. to 5 HP.; and in cross-channel steamers making short passages with high forced draft in the boiler-rooms, cylindrical boilers, and quick-running engines of short stroke, it rises to 10 HP. per ton. The last-mentioned conditions would not, of course, be applicable to long sea voyages.

Forced draft in the boiler-rooms is an old invention, and for the last quarter of a century it has been largely used as a means of accelerating evaporation and increasing power. Previous practice in torpedo boats and small craft led to its application in larger vessels of all war fleets. The "closed" stoke-hold system was chiefly used, powerful fans supplying air and maintaining a positive pressure of varying amount according to the rate of evaporation required. With cylindrical boilers in ships of the Royal Navy the air pressure is not above ½-in. of water for long-distance steaming, and 1 in. for short runs of six to eight hours. Formerly 2 ins. of pressure were permitted, but the boilers suffered. With 1 in. pressure it is found possible to obtain, without injury to the boilers and for considerable periods, about 20 to 25% more than the "natural draft" power without sensible decrease in fuel economy.

Higher steam pressures and grades of expansion combined with more efficient engines have resulted in large economies of fuel. The best direct-acting engines in screw steamships of 1859 with 20-lb. to 25-lb. pressure required from 3¾ lbs. to 5 lbs. of coal per indicated HP. per hour. In the mercantile marine, about twenty years later, this had been reduced to about 2 lbs. as an average with compound engines; at present it is about 1.5 lbs. for ocean-going steamships with triple and quadruple-expansion engines. There are well authenticated instances where long voyages have been performed under economical conditions with an expenditure of 1.25 lbs. to 1.4 lbs., and in some of the fastest passenger steamers 1.5 lbs. to 1.6 lbs. For warships the proportionate expenditure of coal is somewhat higher than in merchant ships.

FOUR-STAGE AIR COMPRESSOR FOR 850-LBS. PRESSURE.

An air compressor of the four-stage type, with a receiver pressure of 850 lbs., and a capacity of 400 to 500 cu. ft. per minute, is an interesting machine recently built for the Oliver Iron Mining Co., and installed at the Aragon mine at Norway, Mich. The machine is for the purpose of supplying compressed air for locomotives for the mine haulage system. It was built by the Sullivan Machinery Co., of Chicago, and we are indebted to the builders for information and photographs. Under test at the works it ran continuously with a pressure of 1,200 lbs. and even as high as 1,250 lbs. per sq. in.

The machine consists of a cross-compound condensing Corliss engine of 21 HP., built for work at a boiler pressure of 150 lbs. Behind each steam cylinder are the tandem air cylinders. The steam cylinders are 12 and 22 ins. diameter. The first and fourth air cylinders are tandem to the low-pressure steam cylinder, while the second and third air cylinders are tandem to the high pressure steam cylinder. The stroke of all cylinders is 30 ins. Between the steam cylinders is a reheating receiver, containing a coil for reheating the steam during its passage from the high-pressure to the low-pressure cylinder. While this practice is of course very essential to the economical operation of engines of this type, it is especially important for an engine running in connection with an air compressor, as the speed is sometimes very low, and condensation would consequently be very great unless the reheater was used. The cylinders are clothed with 4 or 5 ins. of magnesia covering, and then lagged with heavy steel plate, while the rectangular box jacket is also packed with the magnesia. The pistons are fitted with adjustable bull rings.

There are two eccentrics to each engine, one operating the wrist plate with steam and exhaust valve connections, and the other operating the intake valve on the air cylinder next to the steam cylinder. The speed of the machine is from 10 to 125 revolutions per minute, and is varied by means of an automatic governor acting on the automatic cut-off mechanism of the engine valve gear. The speed is thus automatically varied according to the amount of air drawn from the receiver. On the shaft is a flywheel of sufficient weight to maintain a uniform speed when running at 10 revolutions per minute.

As already noted the compressor was designed for an air pressure of 850 lbs, in the receiver, and it is of the four-stage type, with the air cylinders so arranged that the work done in the high and low pressure steam cylinders is nearly equal. The four air cylinders are single acting. In the intake and second cylinders (next to the high and low pressure steam cylinders, respectively), where the air pressure is lowest, it is compressed against the front heads. In the third and four cylinders (at the rear), where the pressure is the greatest, the air is compressed against the back heads of the cylinders. In this way the use of stuffing-boxes and piston rod packing under the heavy pressure is avoided.

The pistons in the intake and second air cylinders are of the adjustable bull-ring type, as in the steam cylinders. The pistons in the third and fourth air cylinders are each made in the shape of a straight ram or plunger, and fill the cylinders for their entire length. They are also povided with a special spring packing. Special provision is made for the lubrication of these pistons, and in view of the fact that they fill the whole length of the cylinders the air cannot leak past them.

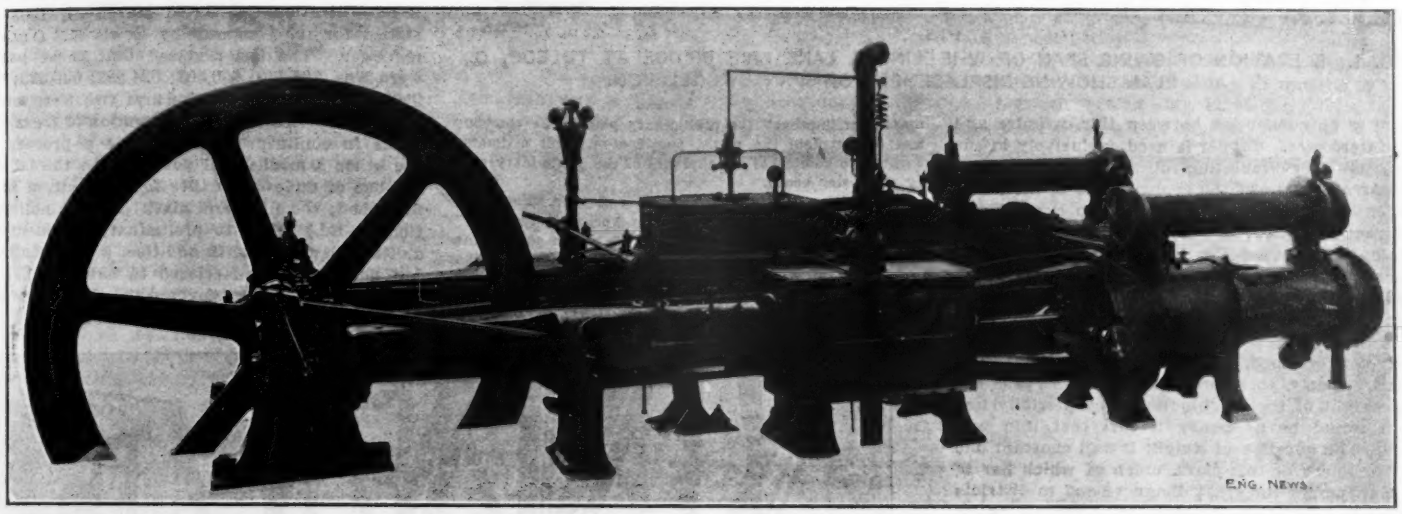
The suction valves in the intake and second cylinder are of the Corliss pattern, and are operated by eccentrics on the main shaft, as above noted. The discharge valves of these cylinders are of the poppet type, and have the valve and valve seat located inside of a removable cage, being held in place by a hand-hole plate. When this plate is removed, the cage containing the valve and seat can be removed by hand from the recess in which they are located without even the use of eyebolts. The pressure on the hand-hole plates forms a tight joint between the cylinder head and the valve cage. This plan avoids making the valve seats against part of the cylinder head. When the seat becomes worn or leaky, the loose cage with valve and all can be removed, a spare valve and cage being kept on hand. The valve removed can then be ground and fitted, and used to take the place of the next one which becomes leaky. By using a spare valve seat and cage, one can be taken out and changed each week, if required, as it requires no longer to make the change than the time required to remove the three nuts that hold the hand-hole plates in place.

By this method, these valves can be kept tight at all times. It is claimed that where part of the cylinder head forms the valve seat, several grindings will destroy the proper shape of the seat to such an extent that when a new valve is inserted it will not fit the seat properly, and the result is that the valves and valve seats are continually leaky.

The suction and discharge in the two high-pressure cylinders are of the poppet type. The valves are made of nickel steel. The recesses in which these cages are inserted are tapered, and the outside of the valve cage is ground to fit the tapered recess. The cages fit on the outside for their entire length, or the thickness of the head, as it is not advisable to depend on a narrow joint or shoulder for an airtight fit under heavy pressures. With the smallest amount of leakage across a point of this kind with so heavy a pressure, it would soon cut away the metal, and a very small leak would impair the efficiency of the machine. With these cages fitting their entire length, and ground to fit like a plug cock, all danger of leakage or cutting away the metal with the high pressure is eliminated. The poppet valves in all of cylinders are cushioned, so that they work without noise or clicking.

The water jackets around the intake and the second cylinders are so designed that a body of water 3 ins. in thickness circulates around the cylinder liners. The amount of water space around the third and fourth cylinders varies from 4 to 6 ins. betwen the outer shell and the cylinder liner, which allows for the free and unrestricted circulation of cold water around the cylinders. The liners in the air cylinders are independent of the cylinder castings and are pressed into the outer shells by hydraulic pressure, so that in case of cutting or scoring from lack of oil, either one of these liners can be removed and new ones inserted in their place.

The air enters through the mechanically moved intake valves in the front end of the forward air cylinder, located behind the low-pressure steam cylinder. When compressed, it is discharged through a pipe on the side of the cylinder into the



FOUR-STAGE AIR COMPRESSOR FOR THE OLIVER IRON MINING CO.
Sullivan Machinery Co., Chicago, Builders.

first intercooler, located below the floor line. From this intercooler it is taken into the second cylinder, located on the lefthand side of the machine and behind the high-pressure steam cylinder. After this second compression it passes through the intercooler located on top of the second and third cylinders, and the third stage takes place after passing through this intercooler. It is then discharged through a pipe passing under the floor line from the third cylinder, and enters the intercooler located on the righthand side of the machine, and on top of the intake cylinder and the fourth cylinder. This intercooler is separated into two compartments so that the air travels in the shape of a loop through the intercooler tubes, and is then drawn into the fourth or final cylinder, where it is compressed to a pressure of 850 lbs. per sq. in. The front end of this intercooler rests on the upper side of the intake cylinder, but there is no connection between this cylinder and the intercooler. Copper is used exclusively in the intercooler for circulating-tubes for the cold water. The arrangement of the copper tubes in the intercooler is such that they are free to expand and contract from heat and cold without affecting the joints, so the expansion and contraction can take place without causing leakage.

All castings are of so-called semi-steel, which is iron having a certain proportion of steel added to it in the cupola, the resultant metal being strong and close grained, while easily machined. The wearing parts, therefore, give better service and the weight of the machine is also materially less than would be necessary if soft cast iron was used. The question of weight is an important one in machinery of this class, much of which has to be transported for great distances and in districts where freight rates are high. The cranks, crank shaft, connecting rods, piston rods and all motion rods and pins for the valve-gear are made of steel. All boxes and bearings for the valve gear are of phosphor bronze, and are adjustable for wear. The piston rods are packed with metallic packing. Sight feed lubricators are provided for the high and low pressure steam cylinders.

While this machine is of special design, it represents a class suitable for heavy duty and high pressure, and may be built with modifications to suit the varying requirements of purchasers. Thus a considerable saving in weight and cost may be effected by terminating the foundations at the back end of the first pair of air cylinders, and supporting the rear pair on pedestals bolted to the floor, the cylinders merely resting on the pedestals, so as to allow for expansion and contraction. The capacity may be anything desired above 350 cu. ft. of free air per minute, with steam engines from simple to quadruple expansion, and with two to six-stage air compression according to the pressure required.

A REMARKABLE CONTRACT FOR ENGINEERING SERVICES AND WATER FILTRATION PATENTS.

Litigation of unusual interest over a contract between the water board of Wilmington, Del., and the United States Sand Filtration Co. has been in progress during the last few months. The suit arose over a pending payment of $20,000 to the company named as the first instalment due the company for preparing plans for a filtration plant and other important improvements to the Wilmington water-works. The water board authorized the payment, but the city auditor refused to approve it, and some taxpayers applied to the courts for and secured a restraining order to prevent the payment of any money whatever until the legality of the contract could be tested. Later, the company brought suit in a United States court for $100,000 damages for alleged breach of contract.

The contract in question was executed on March 31, 1903, and was printed in full in the Wilmington "Every Evening" of July 17, 1903. A full abstract of the contract, giving all its main features, is presented herewith:

(1) The company agreed to "prepare complete plans, surveys, specifications and details" for "sedimentation basins, filter beds and machinery and buildings connected therewith, clear water basins, pumping station and piping system for conducting water from the pumping station to the filter beds, and thence to the distributing reservoirs, together with drains and all necessary appliances and appurtenances." The company agreed to submit "a preliminary plan" within 30 days of the date of the contract. The city was to have 30 days in which to "supplement, modify or improve" the preliminary plan. The company was to complete the plans, specifications and estimates within two months of the approval of the preliminary plan by the water board.

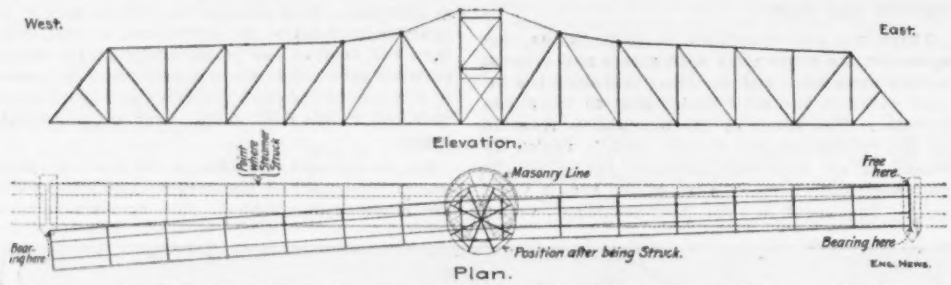


FIG. 1. ELEVATION OF SWING SPAN OF WHEELING & LAKE ERIE BRIDGE AT TOLEDO, O., AND PLAN SHOWING DISPLACEMENT OF SPAN BY COLLISION.

(2) For the services enumerated, and "for supervising the construction of the said water-works, if required," the company was to be entitled to 5% of the cost of the improvements, half of it to be paid on the delivery of the plans, and the balance upon the award of a contract for the improvements, provided a contract was made within six months of the date of the contract with the company for the preparation of the plans. The first payment of 2½% was to be based on the company's estimate of the cost of the improvement. The second 2½% was to be based on the contract price, if a contract was let within the six months named; if the contract was not so let then the other 2½% (and therefore the full 5%.—Ed.) was to be based on the company's estimate.

(3) The company, immediately on the delivery of the plans, was to license the water board and its successors to use the then existing and future patents held by the company "which are or may be in any way related to the filtration of public water supplies." As compensation for said filtration patents the company was to be entitled "to 10% of the entire cost of the proposed improvements shown upon said plans, surveys, specifications and details." Half of this payment was to be based on the estimated cost of the improvements and to be made when the licenses were delivered; the balance was to fall due when the contract for construction was made and to be based on the contract price, provided the contract was made within six months; if not so made, the same rule was to be followed as has been outlined in the case of payment for the plans.

(4) The company was given equal rights with all others to bid on the construction of the proposed works, regardless of when bids might be invited. In case the U. S. Sand Filtration Co. secured the contract it was to give a bond of not less than $100,000 nor more than $125,000 guaranteeing that it would follow the plans and specifications; that all concrete work would be water tight; that the beds would purify not less than 4,000,000 gallons per acre of net area; that filtered water, when the beds were "properly operated," should "contain not to exceed 40 bacteria per cu. cm. on an average for a period of three months; and that on the failure of the filters to fulfil any part of the guarantee the company would, at its own expense, alter or change the work so that the results obtained shall be as guaranteed."

(5) In case the filtration company received the contract for all the improvements it would cancel its charge for plans and supervision.

(6) If the contract for construction was awarded to the filtration company it would at any time have the right to require the formation of a supervisory board, to act in place of a constructing engineer in the case of disputes or controversies. The board would consist of three engineers, one chosen by the water board, one by the company, and the third by the two thus chosen. If the two could not agree upon a third engineer, then the names of three competent engineers would be submitted by the President of the American Institute of Mining Engineers; the water board would cancel one name, the water company a second, and the third engineer on the list would constitute the third member of the supervisory board. The monthly compensation of the supervisory board would be paid one-half by the city and one-half by the U. S. Sand Filtration Co.

The patents involved in the contract abstracted above were described in a letter from the U. S. Sand Filtration Co., dated March 31, 1903, and signed for the company by Lewis K. Davis as manager. The letter stated that these patents were Nos. 705,740; 660,563; 624,893; 636,323; 659,916; 629,446. Of these the first two were said to relate to devices "for the prevention of freezing of fluids in confined reservoirs, one a process and the other a mechanical patent;" the third covers the use of underdrain tiles for the bottom of the filter bed; the fifth and sixth (fourth not mentioned.—Ed.) relate to preliminary sedimentation and auxiliary filters. In addition, a patent allowed but not then issued related to baffle walls, and three patents pending covered the cleaning of auxiliary filters.

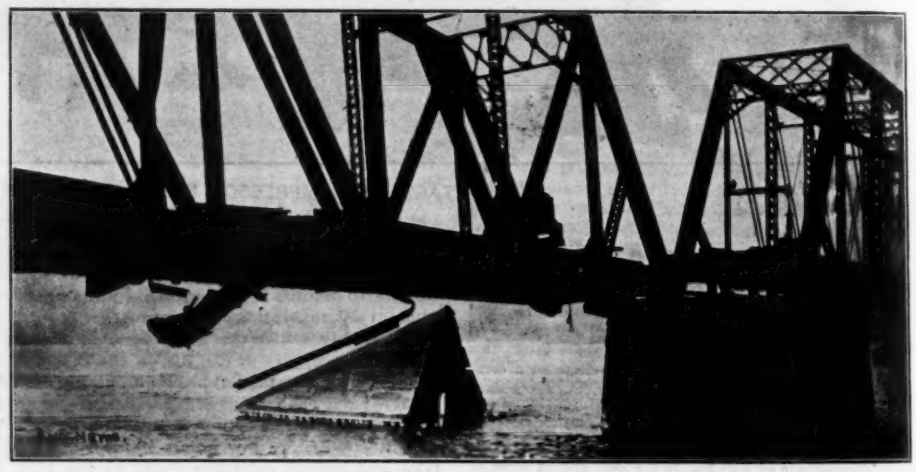


FIG. 2. VIEW OF DISPLACED ARM OF SWING SPAN.

Some comments on this peculiar contract are printed on the editorial pages of this issue.

A NEW CONTRACT.

Since the foregoing was written it has been reported that the old contract has been cancelled and a new one agreed upon. The new contract, it is said, provides for a lump payment of $65,000 for plans and patent rights, and a payment to Mr. Davis of $10,000 for supervising construction. The company withdraws its suit for alleged breach of contract and agrees to give the city a bond guaranteeing the success of its filters.

A COLLISION WITH A SWING BRIDGE AT TOLEDO, O.

By R. G. Manning, Assoc. M. Am. Soc. C. E.*

About 6.30 on the morning of Nov. 12, the freight steamer "Luzon," while going up the Maumee River toward Toledo, struck the Wheeling and Lake Erie R. R. swing bridge in the middle

*Engineer, Toledo Plant, American Bridge Co., Toledo, Ohio.

of the fourth panel from the end. It was a foggy morning, and the boat struck the bridge without any warning.

The swing span is a part of a bridge with four fixed spans of 175 ft. to the west and one fixed span of 175 ft. to the east of the swing span.

Navigation was blocked for some days and the railroad will not be able to use the bridge for several weeks.

By means of scows and jacks the bridge will be lifted back onto the center—turned around over the protection piers and the repairs made. The

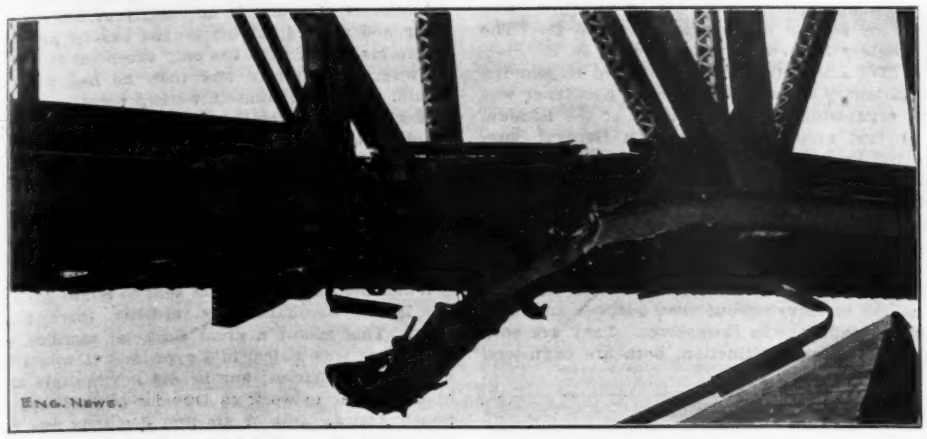


FIG. 3. THE POINT OF COLLISION.

The swing span was built by the Edge Moor Bridge Co. in 1897. It is 340 ft. long and operated by steam power. The table is combined rim and center bearing. The west arm of the span was the one struck.

The accompanying photographs will give a partial idea of the damage done, and of the force of the blow. At the center everything above the bearing wheels and spider ring, that is the entire bridge including the drum, was shoved bodily over about six feet, so that the drum overhung the pier about four feet. The center pedestal, where the pin of the upper part fits into the lower bearing, was lifted out of its socket and carried over with the upper work, the lower part remaining in place a little tilted.

The arm which was not struck remained practically in place except for the displacement at the center and a slight skewing of the end. The other end of the span was skewed about 17 ft. so that one corner of the bridge is just hanging on the pier. The fact of this corner resting on the masonry probably saved the bridge from being completely wrecked by overturning and falling off the center pier. The masonry at this end, where the end rests were in their shoes and the latch in place, was badly damaged. Anchor bolts were sheared off and large stones broken and displaced.

The photograph, Fig. 3, shows where the boat struck. One of the guard rails was broken square off. The section of the bottom chord of this panel on the side struck is broken entirely off at the post, the stringer was forced off of its connection to the beam by cleanly shearing every rivet. The other stringer was bent and twisted together with the lateral, and one lateral was shoved through the web of a stringer. One of the main diagonals of this panel composed of two 15-in. 33-lb. channels, laced, was broken about the middle, and one channel of the other was broken near the top. One side of the other lower chord was also broken. Two of the posts are twisted.

The entire bottom lateral system of this arm was broken, twisted and bent beyond repair. The two end posts of this arm at the center are bent and twisted at the lower point of the portal connection, and the angles of one of these are broken. The top struts and sway struts are bent and twisted. Where this arm joins the tower post there is a decided skewing. The bottom chord on the side which was struck is broken in two at the center of the center panel, and one web near the post in the next panel. The chord on the other side and in the first panel from the center is bent and twisted out of shape, one web broken and beyond repair.

The flange angles of the drum were broken in several places. At one place there are two complete fractures of the flange angle, only about four inches apart and with one rivet between the breaks. Many bolts and rivets were sheared as clean as could be done with the hammer.

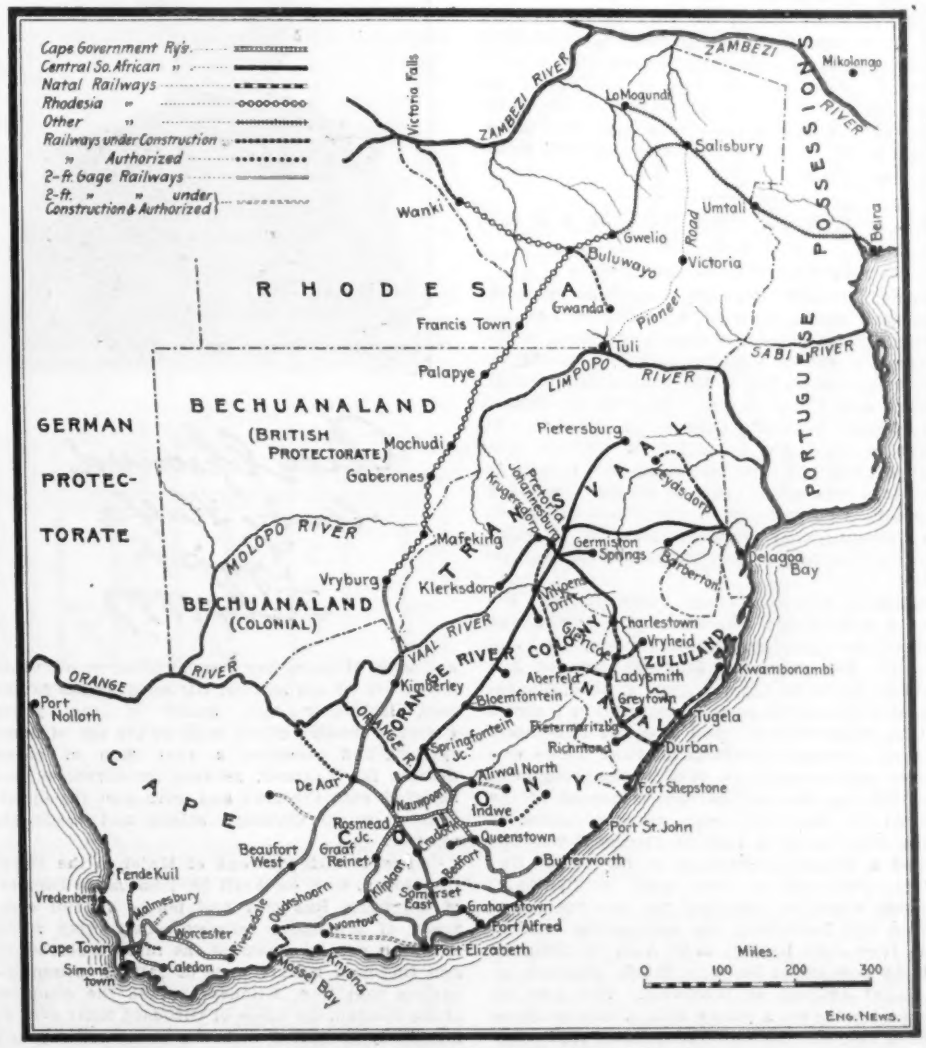
material is soft steel and most of the fractures are sharp, clean breaks without any apparent reduction of area

THE RAILWAYS OF SOUTH AFRICA.

The railways of Cape Colony, according to the annual report of Mr. T. S. McEwen, General Manager of the Cape Government Railways, had an aggregate extent of 2,317 miles at the end of 1902. This, it must be remembered, is for the lines within the colonial boundary, and does not represent the entire system of South African railways. The accompanying map, prepared from one which accompanies the above report, shows the present railway system of South Africa, and it will be noted that at two points it reaches very close to the Zambesi River, while one line is under construction right to the river, at the Victoria Falls. It is this line which will eventually be extended north of the Zambesi to meet the lines built south from the Nile country, to form a railway from Alexandria (on the Mediterranean) to Cape Town. It will be noted also that as a result of the Boer War, the Orange Free State and Transvaal republics are now the Orange River and Transvaal colonies, and their railway systems are now under the management of the government under the name of the Central South African Railways. Their operation, as well as that of the Rhodesia Ry., to Bulawayo, has been undertaken by the Cape Government Railways.

Improvements in grade and curvature are being made at various points, where the economic results in operation and the increased capacity of the lines will amply compensate for the expenditure. In consequence of the introduction of heavier engines and rolling stock it has been decided to relay the main lines with 85-lb. rails, utilizing the old lighter rails for some of the new lines and extensions. The main system of railways has a gage of 3 ft. 6 ins., but a few years ago the government adopted a policy of building some new lines of 2 ft. gage. This is now found to have been a poor policy.

The Cape Government Railways now have 469 locomotives, and these average 21 months of service between repairs. Mr. H. Beatty, Chief Locomotive Superintendent, reports that this is quite



MAP OF RAILWAY SYSTEM OF SOUTH AFRICA.

as long as the small-wheeled engines of 3 ft. 6 ins. gage will last in an efficient state. In addition to work on these engines, however, the shops repair and erect locomotives for the Central South African Railways. Ten English engines of the

twelve-wheel type (built by Neilson, Reid & Co.) are now in use, and give satisfactory results. They represent about the limit in the way of power obtainable on the 3 ft. 6 ins. gage with a firebox placed between the wheels, as a longer firebox cannot be properly fired. Various types of wide firebox, eight coupled engines are now being built. As to the 14 American consolidation engines, built by the Schenectady Locomotive Works, Mr. Beatty states that "the work in these engines is, in some respects, rough, and they were troublesome to erect, but taken all round they are good engines. The tandem-compound consolidation engine built by the Schenectady Locomotive Works promises well, but it will require extended experience of its working to enable fair comparison to be made between it and the simple locomotives."

Great difficulty is experienced with the water supply for the locomotives, the water being usually very bad for boiler purposes and causing continual trouble with the tubes and fireboxes. Mr. Beatty calls attention to the expense due to boiler failures and the delays which they cause to traffic, and recommends that an engineer should be appointed to give his whole time to the question of water supply. An extensive series of borings for water has been made, but without much practical result as to quality, the water being often very bad, but nothing appears to have been done as yet in the way of water purification or special treatment at the water stations. The wells are rendered necessary, however, by the growth of traffic in a country where the rainfall is so uncertain. Some of the borings strike water while others are failures. On certain portions of the lines tank cars or extra tenders are used to carry a supply of water.

Rail renewals during the year, as reported by Mr. J. Brown, Engineer in Chief, amounted to 4,753 tons. On the Eastern Division, the wear of rails on curves has been very severe, and it has been decided to use tie-plates under the 60-lb. rails, and to replace these rails later with 85-lb. rails. In all, 174,427 wooden ties and 4,174 metal ties were removed.

LIEUT. COLONEL SIR PERCY GIROUARD, K. C. M. G. D. S. O., R. E.

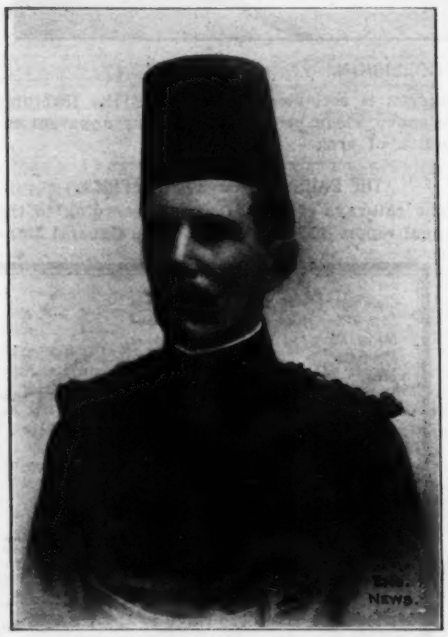
By Captain J. D. Chartrand.*

Percy Girouard, a French-Canadian by birth, was born in the City of Montreal on Jan. 26, 1867. He was the son of Justice Girouard, of the Supreme Court of Canada, and he received his preliminary education in the schools of Montreal, Nicolet and Three Rivers. In 1882 he entered the Royal Military College of Canada, at Kingston, Ont., but he did not exhibit any marked ability at this institution, and though he graduated with a fair grade in his class, he failed to obtain a commission in the Royal Engineers. His contemporaries remember him as a calm, sturdy youth; rather slow, but industrious and reliable.

Failing to enter the army, Percy Girouard became a subordinate member of the engineering staff of the Canadian Pacific Railway Co., and here, for two years, he studied, observed and worked. He made careful plans of the principal bridges and other important engineering features of that great railway, and laid the foundation for that thorough knowledge of detail which was a later characteristic of this brilliant engineer.

In 1888 the British Government placed at the disposal of Canadians some extra commissions in the Army, and on July 28, Girouard was appointed a Second Lieutenant in the Royal Engineers. He was at first sent to Chatham, England, where he remained for two years, extending and perfecting his engineering studies. Then, from July 1, 1890, until Aug. 14, 1895, he held the position of Railway Traffic Manager at the Royal Arsenal, at Woolwich. This was an important office for a young man of twenty-three years of age, but his administration of that office at once justified those who placed him in charge. Lieut. Girouard became the very life and soul of his department; in less than one year he had greatly improved the service, and by various devices he had saved both money and time in the handling of trains and the general operation of the roads. His ambition next led him to formulate a vast scheme of defence for England by means of a coast-line railway carrying guns mounted upon trucks. This scheme—which has been since partially carried into effect—brought Lieut. Girouard prominently before the English military authorities, and his proposition was made the subject of an article written for "The Fortnightly Review" by Col. Bowall, R. E.

In 1896, Lieut. Girouard was called to join the expeditionary force which General Kitchener was then organizing for the conquest of the Soudan. It at first seems strange that a General, surrounded by a full staff of able engineers, should have selected as his "alter ego" a young lieutenant only twenty-eight years old. And the only explanation lies in certain affinities between Kitchener and Girouard; affinities of character, of profession and of blood. Both are stern men, silent and cool, of decided purpose and doggedly tenacious in carrying out that purpose and with implicit confidence in themselves. Tney are both careless of social distinction; both are engineers,



Percy Girouard
Wady Halfa
Egypt
July 1897

and each of them has French blood in his veins, Kitchener by his mother, Girouard by his father. Gen. Kitchener had heard of the young French-Canadian officer who, at the age of twenty-four, had conceived a vast plan of coast-defense for England; he sent for Girouard, was satisfied with the man and gave him the opportunity which Girouard seized and made the most of.

Girouard, with the rank of Major in the Egyptian Army, was, on April 10, 1896, made Director of Egyptian Railways and placed in full command of the entire railway constructing force, and as it was by means of the rapid construction and thorough maintenance of railway communications that Gen. Kitchener made the conquest of the Soudan, the name of Girouard must ever be intimately connected with this great military and engineering achievement.

The construction of the Wady-Halfa Railway, a line crossing the Nubian desert and saving about 600 miles of transportation around a great bend of the Nile, must stand out as one of the greatest efforts of engineering science, human endurance and pluck. Without entering into the detail already known, it is only necessary to recall some of the difficulties of the task. Girouard was facing over 600 miles of flat, burning sand; with no water, no wood, no stone or resources of any kind, except such as could be brought from the rear. But Girouard made an elaborate plan of the construction; foreseeing everything, even to the number of spikes to be used; provided everything and carried out his project exactly according to his plans, with the only exception that the railway cost slightly less than he had said it would. Girouard himself worked night and day, seeing to every detail. His comrades were invalided home or buried in the sands, but he remained. When water failed he bored for it and got it; when material did not come fast enough from England, he transformed and used all the obsolete railway stock in Egypt; and he did this work with the ignorant fellaheen and savage prisoners of war, and the work was done well.

When Gen. Kitchener was sent to South Africa, in 1899,* Girouard was ordered there likewise. This meant a great financial sacrifice, as his salary was £2,000 in Egypt, and it would be only £600 in Africa; but he did not hesitate and at once went to work as Director of Railways in South Africa. One of his first demands was for duplicates of all the bridges liable to be blown up by the enemy, and these duplicates were to be sent to the front at once. As English bridge builders could not deliver them all in the time required, Girouard insisted that some of the contracts should be given to American firms. This action caused him to be bitterly criticised in England; but he gained his point and secured his bridges. Events justified his precautions, for many bridges were blown up, and had it not been for the fact that duplicates were close at hand, months, instead of weeks, would have been required for their replacement. During the rebuilding of these bridges, Girouard resorted to some most daring temporary crossing of streams, starting with gradients 100 ft. above the streambed and rushing his trains down one side and up an equal gradient on the other, without any recorded accidents.

In this work, Girouard had also asked that he be given an absolutely free hand and the whole and undisputed command of all railway forces in the field, with no interference whatever either from the home Government or from the General commanding in Africa. Though this request placed under him hundreds of officers who were his seniors in rank, he again gained his point. It is related of him that while he was rebuilding a bridge, Gen. Kitchener came upon the scene and made some remarks concerning the structure; Girouard sharply replied: "Who is building that bridge, Sir, you or I?" The great Sirdar simply turned about and walked away; but, probably, no other officer in the British Army would have dared to answer Kitchener in that tone.

In recognition of his services to the Government, Girouard received the honor of Knighthood on April 20, 1901.

Sir Percy Girouard remained as Director of Railways, South Africa, until June 30, 1902, and on July 1, 1902, he was appointed Commissioner of Railways of the Transvaal and the Orange River Colonies, in civil employ, at a salary of £3,500. This position he holds at the present time. On Sept. 10, 1903, he was married to Miss Gwendolen, daughter of Sir Richard Solomon, K. C., late Attorney-General and Commissioner of native affairs for the Transvaal Government, and now legal adviser for the various South African Governments. Sir Percy is now taking a well-earned vacation in England.

Sir Percy Girouard has the unprecedented honor in the British Army of having been made—for merit—a K. C. M. G. and a Lieut. Colonel at the age of 34 years. In addition to his title of D. S. O., conferred Nov. 18, 1896, he has received several foreign decorations.

*Late of the French Army, and Professor at the Royal Military College of Canada, Kingston, Ont.

STEEL-FRAME, SIDE-DOOR SUBURBAN CARS: ILLINOIS CENTRAL R. R.

In our issue of Sept. 3 we described and illustrated the new steel-frame cars of the side-door type which have recently been built at the shops of the Illinois Central R. R. to the designs of Mr.

A. W. Sullivan, Assistant Second Vice-President, and Mr. Wm. Renshaw, Superintendent of Machinery. We now supplement that article by particulars of the steel-frame construction.

From Fig. 1, which is a half plan of the underframe, it will be seen that there are four longitudinal sills of 9-in., 21-lb. I-beams, with end sills of 9-in. 25-lb. channels. Between these are 7-in. I-beams over the bolsters and 6-in. I-beams over the needle beams, which latter are 7-in. I-beams under and riveted to the sills. Diagonal members of 4-in. channels extend from each corner of the frame to the intersection of the front bolster and center sill. Large connection plates are used at the points of attachment of the diagonals and longitudinal sills to the end sills. The underframe is stiffened by four truss rods, the ends of which are attached to pins in heavy straps passing over

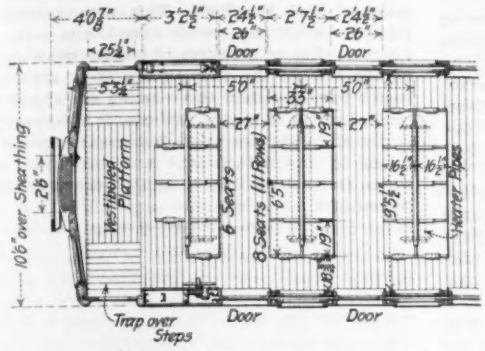


Fig. 3. Part Plan of Side-Door Suburban Car, Showing Arrangement of Seats and Doors.

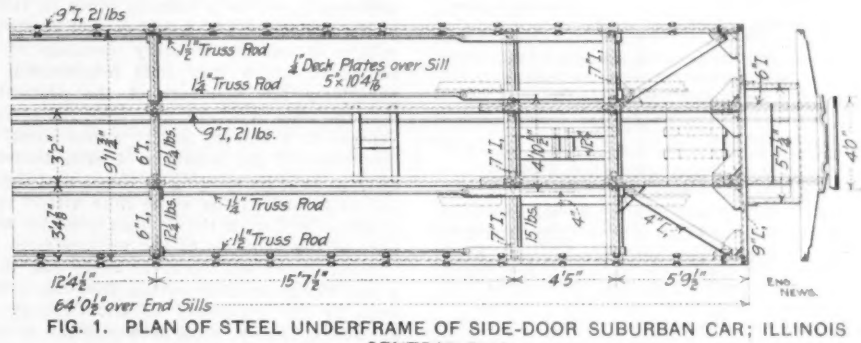


FIG. 1. PLAN OF STEEL UNDERFRAME OF SIDE-DOOR SUBURBAN CAR; ILLINOIS CENTRAL R. R.

versely on the side sills and spaced 11 ins. apart. On the outside and inside of these posts, four triangular gussets of steel plate ¼ × 15½ ins. are riveted to the flanges, tying them firmly together. The corner posts are riveted securely to the side sills and to the upper plates with angle connections.

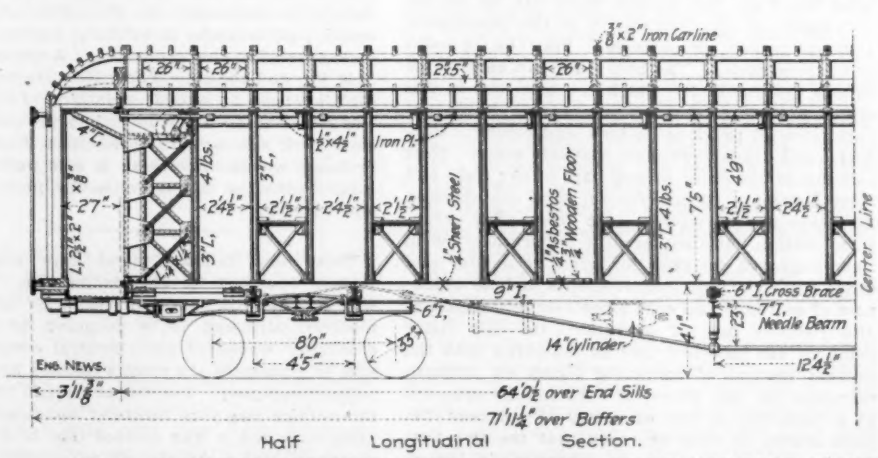
The space between the corner posts and the adjoining side-door posts is braced with a double set of diagonal bracing, formed of 1¼-in. angles in three vertical panels, and riveted to the gusset connections. This arrangement of corner bracing gives stability to the upper frame and forms a collision bulkhead of great resistance. Across each end of the car, the corner posts are connected by ¼-in. gusset plates to angles 5 × 4 ins. They support oak end plates, to which are secured the side arms for the buffing mechanism of the upper portion of the vestibule diaphragm. Diagonal braces of 4-in. channels are riveted to the corner post and to the extreme end at the side plates, which extend beyond the corner posts of the body of the car to the corner post of the vestibule carried by the platform end sill. The vestibule corner posts are further reinforced by upright angles ⅜ × 2 × 2½ ins., with flanged ends, which are bolted to the platform sills and at their upper ends riveted securely to the side plates and the end braces.

The carlines are of iron, ⅜ × 2 ins., and are placed directly over each set of side-door posts, each carline resting directly on the side plates and being secured to each plate by four ½-in. rivets; these rivets pass through the forged foot of the carline, the plate and the forged ends of the channel door posts, tying them all securely together. There is thus formed a continuous connection of metal framing throughout the entire body of the car.

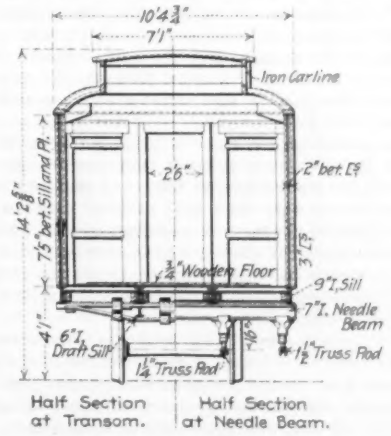
The exterior sheathing is of vertical strips of poplar, 2½ ins. wide, and the interior finish is of mahogany. Special arrangements have been devised for attaching the exterior and interior sheathing to the metal frame. Within the hollow of the channels forming the posts of the side-doors and windows, strips of 1½-in. hard maple were placed before the posts were assembled. The channel posts were then placed upon the bed of a planer with the maple filler upwards, and with a specially designed tool the edges of the channel flanges were split longitudinally to a depth of 3-16-in. The inner portion of each flange was then rolled down cold and turned over upon the filler, compressing and firmly enclosing it within the channel walls without the use of screws or bolts. Between the channel posts below the windows, horizontal nailing strips of oak, 1½ × 3¼ ins., are tightly fitted and bolted to the metal frame, and on top of the metal plate nailing strips of hard pine, 1½ × 4 ins., are tightly fitted between the metal carlines and bolted to the plate.

Between the door posts, threshold plates of malleable iron are tightly fitted, with curved lugs hooked over the outer flanges of the side sills, and the backs of the plates are screwed fast to the floor. There is thus formed a secondary system of continuous horizontal bracing throughout the walls of the car, adding materially to the resistance offered to a raking, corner or end thrust above the level of the floor. On each side of the metal carlines, nailing strips of poplar, 1¼ × 2¼ ins., are bolted and framed into the deck sills and plates and to the nailing strip on top of the wall plates. The roof is of 13-16-in. poplar, nailed to the strips in the usual manner. The floor is laid in three courses; first the ¼-in. steel plates forming part of the underframe, upon which is a ¼-in. layer of asbestos covering surface. Upon this again is a light flooring of wood, in tongued and grooved strips, ¾ × 2¼ ins., laid crosswise and bolted to the steel floor underneath.

The arrangement of the seats, which was described in our former article, is very clearly shown



Half Longitudinal Section.



Half Section at Transom. Half Section at Needle Beam.

FIG. 2. ELEVATION AND CROSS-SECTION OF STEEL-FRAME SIDE-DOOR SUBURBAN CAR; ILLINOIS CENTRAL R. R.
A. W. Sullivan, Assistant Second Vice-President. W. Renshaw, Superintendent of Machinery.

the bolsters. These rods are adjusted by means of screws in the struts, enabling the struts to be lengthened or shortened as required. Over the frame is a continuous deck or floor of ¼-in. steel plates, 5 ft. long and 10 ft. 4 1-16 ins. wide, these plates being riveted to the sills. Under the center sills and extending from the bolsters are 6-in. I-beam draft sills.

The upper framing is also of steel, and is shown in Fig. 2. The posts are 3 × 4-in. channels, with solid forged ends; the lower ends are riveted to the top flanges of the side sills, and the upper ends are riveted to an iron plate ½ × 4½ ins., which extends in one piece throughout the length of the car and the vestibules. The channels are spaced to form the window and door posts, and are set back to back 2 ins. apart, so as to form hollow side walls, within which slide the doors. Below the windows, a girth brace formed by a steel 1¼-in. angle is riveted to the posts, with gusset connections, to which the diagonal bracing of 1¼-in. angles and ¼ × 1¼-in. flat steel bars is riveted. This bracing is shaped at the lower end to form a foot, which is riveted to the lower part of the channel post and to the top flange of the side sill, thus reinforcing the post in its connection with the sill and forming a braced panel between each of the side-door openings. The corner posts consist of two 4-in. 5¼-lb. channels set trans-

in Fig. 3. The clear inside width of the car is 9 ft. 5½ ins., and the double benches of seats are 6 ft. 5 ins. wide, leaving an aisle 18¾ ins. wide at each side. These benches are 5 ft. apart, c. to c., or 27 ins. in the clear, and each has eight individual seats, back to back. There are 11 of these sets of seats, but at each end is a set of six seats, as shown, so as to afford access to the vestibules. This makes a total seating capacity for 100 passengers, but it is taken for granted that the cars will be crowded with standing passengers during the busy hours of morning and evening traffic.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

The most notable international gathering of engineers ever held in this country, if not in the world, will take place in October, 1904, when a World's Engineering Congress is to be held at St. Louis, in connection with the great exposition. As already announced in this journal, the Iron and Steel Institute is to visit this country next year, and will hold meetings here in conjunction with the American Institute of Mining Engineers. Many of our readers will recall this society's previous visit to this country, in 1890, and the notable meetings which were then held in New York and later in Pittsburg. Foreign meetings are no novelty, however, in the history of the Iron and Steel Institute, which has held meetings since its visit to this country in Spain, France, Germany, Belgium and Sweden.

A much more remarkable event is forecasted in the announcement that the Institution of Civil Engineers is to visit the United States next year. This Nestor among the engineering societies of the world has not only never before held a meeting in a foreign country, but, so far as we recall, it has never held a formal meeting in England outside of London. The shattering of precedents involved in this radical departure is all the more remarkable in that the chief agency in bringing it about appears to have been our own American Society of Civil Engineers. We quote as follows from the recent annual address of Sir William Henry White, President of the Institution, in which the formal announcement of the proposed visit was made as follows:

> An invitation to visit America was received some months ago from the American Society of Civil Engineers, who wished to return in New York the courtesies it has been the privilege of this Institution to show to American engineers in London on two recent occasions. Steps were taken by the Council to ascertain the views of members, as such a visit was unprecedented in the history of the Institution, and the replies were of a character which induced the Council to accept the very cordial invitation that had been received. The time will be fixed so as to enable those of the party who desire to do so to take part in the International Engineering Congress which is to be held at St. Louis early in October. Details for the visit have still to be worked out, and this will form one of the occupations of the session.

It is to be hoped that the two great English societies may so time their visit that simultaneous meetings may be arranged for either in St. Louis, in connection with the International Engineering Congress or in New York city.

If this is done, it will be manifestly to the advantage of all concerned if the principal American national engineering societies will arrange the time and place of their annual conventions so as to coincide with the meetings of these foreign societies. Indeed, this will be really a necessity if the foreign visitors are to be welcomed by the American societies as a body and not by mere formal commitees of the membership.

A great international gathering of engineering societies would be a historic event in the annals of the profession and would attract engineers who seldom attend the ordinary meetings of the societies in which they hold membership. Comparatively few members of the profession can take the time to attend more than one society convention in a season, and it would surely be the preference of the members of each American society to have its meeting so timed that they might attend it and at the same time attend the joint sessions held with the foreign societies and take part in the welcome to the visitors from abroad.

The thought will occur to every one that it is a pity the great Engineering Building, made possible by the generosity of Mr. Carnegie, is not already a reality, since it would afford an ideal place in which to receive the distinguished visitors and extend to them hospitalities. It is quite possible, however, that a year hence the building may be sufficiently advanced to make clear to the visitors something of what the future home of the American engineering profession is to be like.

The question of the best type of car for handling crowded and concentrated railway suburban traffic with celerity and safety has been frequently discussed, more particularly in regard to the respective merits of the end-door and side-door types. With the former there is a concentration of crowds at the ends of the cars, causing confusion and delay. With the latter (as hitherto constructed, having transverse compartments), delay occurs while passengers walk up and down the station platform looking for vacant seats, and after the train has started there can be no improvement of the distribution of the passengers, although some compartments may be crowded and others empty. The new suburban cars of the Illinois Central R. R., which are described in this and a preceding issue of Engineering News, depart from all previous designs, and combine side-doors with transverse seats and side aisles. Thus passengers can enter at any part of the train and then distribute themselves to their convenience. The cars are of interest also from their structural design, but their greater importance lies in their improved facilities for handling a busy and dense traffic. These improvements include quickness of entrance and exit, large carrying capacity, and reduced cost of operation. On this latter point we are informed that as compared with the present method of operating trains on elevated railways the new side-door cars can be operated at a reduction in cost of nearly 40 per cent. for train crews. It may be noted that the two first cars have been put in service, and that eight more are now being built at the railway company's Burnside shops, so that there may soon be two complete five-car trains in service.

The desirability of fireproof construction in electric railway cars has many times been pointed out, and this feature is of special importance for cars operated in trains on city lines, where speeds are high and large crowds are carried. Defects in the electrical equipment and more particularly in the motor apparatus under the floor, are always liable to start a fire which may be rapidly communicated to the car. This element of danger has been proved by numerous accidents to single cars and trains on surface, elevated and underground railways, and the most serious accident of this class was a recent terrible disaster at Paris. In the new Illinois Central cars the underframe is entirely of steel, with a continuous deck of ¼-in. steel plates riveted to the sills. This is covered with a sheet of asbestos, upon which is a wooden floor of maple strips bolted to the steel, the construction being such as to prevent trouble from cold in winter. In the cars for the New York underground railway a more complicated system has been adopted. The sills are of the composite type, with steel I-beams and channels sandwiched between timbers, and to the underside of these sills is attached a sheet of insulating fireproof material, covering the entire width of the car. At the trucks, however, this sheet is carried up the sides of the sills and across under the floor, a steel plate being fitted between the insulating material and the floor. This arrangement provides for additional space over the motors. The floor consists of a course of transverse white-pine planks laid on the sills, then a ¼-in. sheet of asbestos felt, and then the wearing surface of longitudinal strips of maple. Of course a fireproof floor is not the only essential, but great care must be taken in the attachment and insulation of all wires and cables, and in the proper protection of the motors.

As shown by the drawings of these cars printed in this issue, they are provided with an upper frame of steel for the sides, ends and roof, and one feature of this is the great strength provided to withstand shocks due to collisions. As the platforms are enclosed by vestibules, and the adjacent cars have thus a large area of contact, telescoping becomes almost impossible. At the same time, heavy horizontal and diagonal bracing in the end panels of the steel side frames provides strength to resist end shocks. To the steel frame is attached an inner and outer sheathing of wood. Metal outer sheathing has been used on some European cars, and might be well adapted to the even temperature of an underground line; but unless supplemented by a good inner sheathing of heat insulating material it might not be so suitable for ordinary outdoor lines in this country, being exposed to extremes of heat and cold. It is pointed out to us by the designers of these cars that while the conditions have not rendered it necessary to construct an entirely fireproof car, the car could easily be made fireproof by the substitution of metal for the interior and exterior wooden finish. The use of some of the modern decorative materials in the form of stamped metal, papier-mache or artificial leather may also be suggested in this connection. A few cars of the Erie Ry. and the New York, New Haven & Hartford Ry. have an outside sheathing of copper, and this has also been introduced in the cars for the New York subway. In these cases, however, the ordinary wooden sheathing is also used, and the copper covering simply takes the place of paint and varnish.

These new Illinois Central cars are not at present equipped for electric traction. The railway operates its suburban traffic by steam locomotives, although it is prepared to introduce electricity whenever the electrical companies are able to guarantee the results insisted upon by the railway company. The use of electric traction for this service was very carefully investigated a few years ago, and it was decided that in order to be successful under the exceptional conditions of the traffic it must fulfil certain specified requirements. At that time the manufacturers of electrical machinery were unable to guarantee this, and the matter was laid aside. Since then, however, there has been great development and improvement in electrical machinery and apparatus and it is now predicted that the introduction of electric traction for the Chicago suburban service of the Illinois Central Ry. will be a matter of the near future.

We note the rather curious fact that of the catalogues and other trade publications which come to this office only about half conform to the standards for size adopted by the leading engineering

societies and railway associations. These standards (which are given each week in a note at the head of the column of "Trade Publications," printed in our "Construction News" supplement), are 3½ × 6 ins., 6 × 9 ins., and 9 × 12 ins. It would seem that these three sizes should offer a sufficient choice of dimensions to suit most purposes. We are impelled to conclude that the manufacturers and dealers who issue catalogues and advertising pamphlets do not appreciate the great advantages of adhering to these standard sizes. Out of a total of 85 trade publications which have been noted in the last seven issues of Engineering News, only 42 approximated to standard size, while 43 were of odd size. In the count we allowed a variation of ¼-in., ½-in., and ¾-in., respectively, from the three standard sizes, so that minor or accidental divergences may be said to be excluded. Some of the cases of odd size are accounted for by the fact that the company issuing the catalogue in question adheres to a uniform size adopted before the three standards noted came into current use. These are only occasional cases, however; as to the others, our perusal of catalogues leads us to believe that nearly always it would have been possible, without difficulty as to cuts, or the like, to use one of the three standard sizes. It would seem that the large proportion of odd-sized catalogues, 50%, is due primarily to a non-recognition of the advantages realized by adopting a standard size. As an offset to this we observe that most of the largest and best-managed concerns have adopted one of the standard sizes (usually 6 × 9 ins.) for their use. This would indicate that the failure to adhere to standard sizes is due chiefly to ignorance and carelessness on the part of the smaller manufacturers, who too often are content to leave the mechanical execution of their trade publications entirely in the hands of the printer.

The proposal to extend the work of the State Board of Health of New York by establishing a system of water supply and sewage disposal inspection, has much to commend it. One of the most praiseworthy features of the plan is to provide for a rigid inspection of the sanitary features of the rural health and pleasure resorts of the State. It is well known, at least among sanitarians and physicians, that the high mortality from typhoid fever in our cities during the autumn is due largely to the infection of persons while on vacations in the country. This infection is by no means confined to farmhouses, with their wells and privies in close proximity. It is also liable to occur at popular and fashionable hotels. Nor is it confined to water supply or defective plumbing and sewerage systems. Could the facts be known, the milk supply would doubtless come in for a large share of the blame. On this account summer resort work done by the New York or any other State Board of Health should include a careful system of dairy inspection.

The well-nigh universal complaint with reference to the street railway systems of the Greater New York and vicinity is poor service due to the lack of power. The New York Railroad Commission has recently issued a statement embodying the result of its investigations of New York electric power stations. It reports that the Interborough Rapid Transit Company's Manhattan Elevated Railway lines, the New York & Queens County Ry., and the Brooklyn Heights R. R. Co., are all short of power-station equipment to meet the demands of their traffic. In the case of the last-named company, it is stated that by Dec. 15 next the company will have a total power-station capacity of 40,620 KW., whereas its demand for current in the coldest winter weather, when car heaters are turned on to full capacity, will not be less than 51,568 KW. Until the two new power-station units which are to be in operation by Dec. 15 are put in service, the company has only 35,220 KW. actually available.

On the other side of the North River, on the lines of the street railway companies operating in Newark, Jersey City, and other towns in the vicinity, the same complaint is heard of poor service due to lack of power for operation. We doubt not that a similar state of affairs would be found on a considerable proportion of electric railway systems throughout the country.

Part of this shortage of power is unquestionably due to the strikes in the machine trade and in the building trades, by which both the work of building new power stations and their equipment with machinery has been greatly delayed. There is one element in the situation, however, which has received little attention, but whose effect is far reaching, and that is the influence of electric car heaters on the maximum power-station load.

It has been estimated, we believe, that the current required to fairly heat a street car in severe winter weather will be fully equal to the amount required to drive its motors. Electric car heating has been lauded as a cheap system, but we question how many of the railway companies installing it have taken into consideration each and all the items of cost involved in providing the current necessary for heating cars without encroaching on that necessary for their propulsion. It is not merely the coal bill for the electric current required for heating. It is the machinery required to furnish that current, the buildings and real estate required to accommodate it, the transmission lines required for its distribution, and the maintenance, in season and out of season, of all these. It is very likely true that electric car heating is here to stay, but that by no means proves that its original adoption was a wise course. Had a very small part of the investment which has been made in electric car-heating systems been devoted to the development and installation of a satisfactory independent heater, there is reason to believe that the final result would have been much to the advantage of street railway owners as compared with the present situation.

A ONE-SIDED CONTRACT FOR A WATER FILTRATION PLANT.

The city of Wilmington, Del., appears to be particularly unfortunate in recent years in the conduct of some of its public improvements. Passing over its difficulties with the matter of garbage furnaces from time to time, particular attention is now directed to its experience with water purification works and plans.

In our issue of Aug. 13, 1903, we noted that the water filtration plant at Wilmington had been shut down. That plant was put in operation in the latter part of 1894, and was described at length in Engineering News of Sept. 8, 1898. The system was of extremely peculiar design. After the water had passed by bundles of revolving iron rods, and after air had been introduced into the water, the latter flowed to a tank designed to effect sedimentation and then passed directly upwards through shallow filters of gravel and sand. The rate of filtration, with no allowance for beds out of use for cleaning, was more than 43,000,000 gallons per acre per day.

When we described the plant we said, in substance, that we could see no reason why it should do what was claimed for it.

Apparently, the filters never came up to expectations, and, finally, as stated above, they were closed down.

Shortly before the latter action the water board entered into a contract for plans for new filters, for extensive additional improvements to the works, and for rights to certain filtration patents.

It might have been supposed that after such a costly experience the city authorities would have fought shy of further patent filtration processes and that it would have done as other cities do, viz.: obtain the advice of a competent engineer as to the best plan to adopt for the much needed improvement of its water supply.

Instead of pursuing any such sensible course, however, the city proceeded to adopt another patented system of water purification and it entered into a contract for this system, as noted above, in which it put itself largely at the mercy of the contracting company. The contract is printed in substance elsewhere in this issue; and wholly without prejudice to the merits or demerits of the patented devices involved, it must be said that a more one-sided contract between a municipality and a private company would be hard to find.

We have freely criticised in these columns contracts which we deemed unfair to the contractor; but we are equally ready, as in the present case, to criticise contracts so drawn as to be unfair to the corporation or municipality for which the work is to be done.

In the Wilmington contract the following features appear particularly objectionable:

(1) A company controlling certain patented devices was given a contract to make plans for engineering work involving the use of these patents. It was guaranteed equal rights with others in bidding on the construction work for which it was to make plans; and it was provisionally engaged to supervise the construction in case the contract should be awarded to some other bidder.

(2) Although it was considered essential to include in the contract a provision that if the company were awarded the contract for all the improvements it would enter into a guarantee that its filtration plans would ensure certain bacterial results, no guarantee was required in case the company secured only a portion of the contract work, even if that part were the filter plant. Neither would the guarantee for bacterial efficiency hold if the award for the filters was given to any other contractor.

(3) Although the contract gave the city the right to examine "a preliminary plan," submitted within 30 days of the dates of the contract for plans, and although the city was to be allowed 30 days in which to revise this plan, its further control of the designs stopped there. Moreover, in case the company secured the contract for construction it could demand a board of three engineers to pass on disputed points, but the city could make no such demand.

The curious method for choosing the third of these engineers, in case of disagreement, gave the company a decided advantage over the city; for of three names to be submitted by the President of the American Institute of *Mining* Engineers (a curious selection) the city was to strike out one, and then the company was to strike out another. In other words, the city could say which of three men selected by an outside person it would *not* have, while the company could subsequently choose whichever of the two remaining men it might prefer.

(4) Half of the payment for plans and half of the payment for patent rights was to be based on the company's own estimate of the cost of construction; the other half was to be based on the contract price, which, for the patent rights, might be the company's own bid. In case the construction contract was not awarded within six months of the date of the contract for the plans then the full compensation for both plans and patent rights was to be based on the company's own estimates of cost; but the filter company was not thereby to be barred from bidding whenever bids were invited. The company was to have until the end of four months from the date of the contract, if it chose, to complete plans, specifications, surveys and estimates, thus leaving the water board only two months to prepare its advertisement for bids, publish the advertisement, and canvass bids before the filter company would be entitled to payment of all commissions (15 per cent.) on the basis of its own estimates of cost.

The more the city hastened, the less time other bidders would have to prepare their estimates, and in any case the filter company as a bidder for the contract would have all the advantages due to making surveys, preparing plans, and drawing specifications, with the strong probability that it would supervise construction if any one else got the contract. Furthermore, it would have the opportunity, as well as the incentive already named to seize it, of making its published estimates of cost high and then underbidding its own estimates.

(5) And in some respects worst of all: For its patents on certain filter accessories the filter company was to receive 10 per cent. royalties; and those royalties were not to be based on the cost of the accessories, nor even on the cost of the filters, but they were to be based on "the entire cost of the proposed improvements shown upon said plans, surveys, specifications and details," which,

by a reference to the opening portion of the contract, is seen to include

sedimentation basins, filter beds and machinery and buildings connected therewith, clear water basins, pumping station and piping system for conducting water from the pumping station to the filter beds, and thence to the distributing reservoirs.

The 5 per cent. fee for plans, specifications, surveys and supervision was to be waived in case the filter company received the contract, but otherwise its engineering services, combined with patent rights affecting only a small part of the whole improvements, were to be remunerated at the rate of 15 per cent., half of which, and perhaps the whole, would be reckoned on its own estimates of cost! Supposing the company to feel pretty sure of securing the contract for construction, as it well might in view of the conditions already outlined, a high bid would mean both increased construction profits and increased royalties.

The fundamental error of the municipal authorities at Wilmington, both ten years ago and this year, was that they secured no disinterested engineering advice. In the first instance this failure resulted in the expenditure of $100,000 for a filter which we venture to say has been a practical failure as a means of water purification from the start, and whose worthlessness is well shown by its final abandonment in response to the public demand for a better quality of water.

In the present instance the error of a decade ago appears to have been repeated in even worse form.

We have no objection whatever to the use of patented devices as such in engineering work; but the city which adopts any such devices or systems whatever in a field where engineering practice is well defined should only do so under the advice of competent and disinterested experts.

This is so simple and self-evident that it needs no proof; but if proof were needed, the experience of a number of cities in the United States which have experimented with patent schemes of treating water, sewage, garbage, etc., during the past ten years without expert advice and with invariable and total failure is all the testimony that should be needed.

LETTERS TO THE EDITOR.

Central Power Stations and Electric Distribution for New England Water-Powers.

Sir: In your issue of Nov. 5 you publish an abstract of a paper by F. A. C. Perrine, Elec. E., entitled, "Central Power Stations with Electric Distribution in Regions of Small Water Powers," in which he is quoted as saying:

The most notable example that has come to my attention of the wastefulness of low-head development is to be found at Holyoke, where the canals consume space which should be available for good factory sites and where they are losing from 20% to 25% of the entire power developed by reason of the inefficiency of many low-head wheels in series. I claim that it would not be correct to object that in such a case as that of Holyoke the losses in the electrical machinery and transmission would more than counterbalance the increased efficiency of the water-wheels, since we all know that the introduction of the electrical drive will of itself overcome the loss from belting amounting to more than the inefficiency of the electrical machinery and whatever increased efficiency there could be gained by the high head would be clear gain and increased power.

A great many people would be likely to infer from Mr. Perrine's statement that the loss of efficiency by the employment of wheels in series is very much greater than if applied on the single turbine under the total fall available at that place. While he may not overstate the losses on wheels that have been in use for the past twenty years, the modern wheels of later years, at least some of them, are doing very much better than he gives them credit for. If his inefficient water-wheels were used under the total fall at Holyoke, their efficiency, if surrounded by the same advantages that they now have, might be increased 2 or 3%. The principal advantage of the consolidation of the several water falls, is the lessening of the first cost of the power plant. The second important factor would be the saving in the annual maintenance charges. While the improved efficiency item is worth looking after, it is not of so much importance, in the opinion of the writer, as the first cost and the annual maintenance. A number of attempts at consolidation have been brought to mind by Mr. Perrine's paper, in which the cost of the installation of an electric transmission plant, although favorable as to distance, was so great that the income from the power developed, although worth $30 per horse-power per year, was not sufficient inducement for the owners to proceed further after obtaining estimates.

Very truly yours, Asa M. Swain.

223 School St., Lowell, Mass., Nov. 15, 1903.

A proof of the above letter was submitted to Mr. Perrine, and we append his reply as follows:

Sir: I have your letter of Nov. 18, enclosing proof of Mr. Asa M. Swain's letter discussing the question which was raised in my paper before the New England Cotton Manufacturers' Association on the inefficiency of the plant at Holyoke.

Mr. Swain is correct in assuming that I did not intend to convey the impression that there was a loss of efficiency simply by reason of having wheels in series with the same total amount of available head. In addition to the loss which Mr. Swain mentions there is always, in the case of wheels in series, a very considerable proportion of the head which is not available, but which could be made available by the use of a single wheel. This is on account of the necessity for a certain velocity of flow in the tail race in order to clear the dead water away from the wheel and a certain unavoidable velocity of flow in the head race.

Yours truly,

F. A. C. Perrine.

Pittsfield, Mass., Nov. 19, 1903.

An Argument in Favor of Cement Paste as the Unit in Concrete Mixing.

Sir: In Engineering News of Nov. 12 I notice a letter treating of the measurement of cement for concrete. I would suggest a clause in specifications something like the following: The sand and broken stone for concrete shall be used in the proportions of one sand to two of broken stone, and in each cubic yard of concrete there shall be 6 cu. ft. of cement, 1 cu. ft. of cement being that amount of cement which, loose or packed, when mixed with water to the consistency of ordinary mortar, will measure 1 cu. ft.

All cements shrink in volume when wetted, some more than others. If you have a cubic yard of sand and broken stone mixed, and there are 6 cu. ft. of cement voids in it, you cannot fill them with 6 cu. ft. of dry, packed, or loose cement. The amount that any cement will shrink in volume is easily determined, and by using the wet cubic foot as a unit for cement you deal with the material which you have in the concrete, you get the amount of cement into the concrete which was intended to be put there. With the proportions 1:2:4, a volume 1 of cement in the concrete is intended. Using loose or packed dry cement the 1 becomes ¾ or ⅞. Furthermore, when you say that there shall be 6 cu. ft. (or whatever amount is required) of cement in each cubic yard of concrete you wipe out all shadow of doubt in a contractor's mind as to how much cement is required in, say, 1,000 cu. yds. of concrete work.

Stone does not crush uniformly and the sand voids in it vary considerably in consequence, especially if the "run of the crusher" is used, so that a certain amount of a 1:2:4 mixture which would one day make a cubic yard of concrete would, perhaps a week later with a different batch of stone with less voids, make 1⅛ or 1¼ cu. yds. In other words, you would not get a uniform grade of concrete.

Very respectfully,

T. Warren Allen.

Mingo Junction, O., Nov. 13, 1903.

[There are some objections to using cement paste as the unit by which the stone for concrete is measured. Our correspondent says in one sentence that all doubt as to the quantity of cement required in 1,000 cu. yds. of concrete is removed when cement paste is the unit of measure, yet in a preceding sentence he has said:

All cements shrink in volume when wetted, some more than others.

Granting, then, that the shrinkage is an unknown quantity, depending upon the brand of cement used, how, may we ask, does making cement paste the unit of measure serve to clear away all uncertainty in the contractor's mind?

To add water to loose cement is in effect to puddle it, that is, to compact it to a volume not far different from its volume when well packed in a barrel. And for this reason it seems to us that it would be no more likely to create confusion in the contractor's mind to specify packed cement as the unit, and be done with it, than to specify cement paste, whose volume relation to the barrel can only be determined by experiment. The barrel, it must be borne in mind, is the unit of cost to the contractor; hence he must make some assumption as to the relation that cement paste bears to packed cement in the barrel. Since he must make this assumption, we cannot see how he is helped in any way by a specification making cement paste the unit of measure, except in so far as he is assured that loose cement will not be the unit, and that the volume of cement paste will probably not differ much from that of packed cement.—Ed.]

AN INTERESTING EXAMPLE OF WIDE ARCH ROCK TUNNEL WORK AT GENOA, ITALY.

In carrying out the new terminal improvements for the Mediterranean railway at Genoa, Italy, it was found necessary to build a branch tunnel from the new station tracks to the old tunnel on the main line to Spezia. This tunnel had to be excavated through a seamy, stratified rock and underneath a number of heavy buildings, whose foundations came within a yard or two of its crown, and these conditions, coupled with the large cross-section and other peculiar features of the work, made its accomplishment a matter of some difficulty, despite the short distance bored. A plan and profile and some of the details of the tunnel are shown by Fig. 1. Figs. 2 and 3 explain

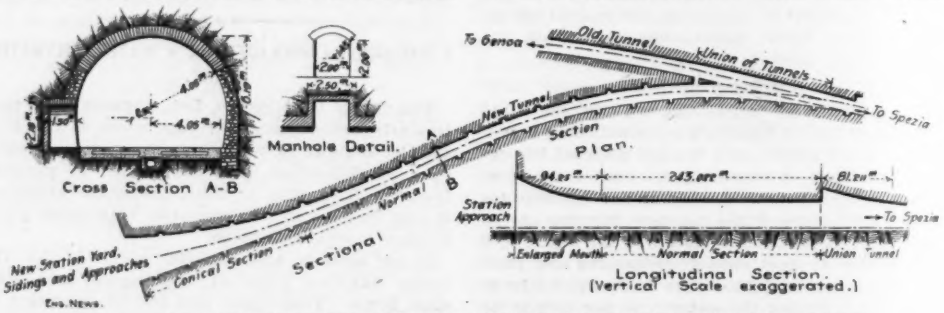

FIG. 1. PLAN AND SECTIONS OF WIDE ARCH ROCK TUNNEL AT GENOA, ITALY.

the method of performing the excavation at the most difficult points.

The new tunnel, as will be seen by Fig. 1, may be divided into three sections, as follows: A conical-shaped mouth at the station end 290½ ft. long, 80 ft. maximum width and 36 ft. high; a central two-track portion 746½ ft. long, 27 ft. 3 ins. wide and 20 ft. 6 ins. high, and a terminal or union section 253 ft. long, 54 ft. maximum width and 29 ft. maximum height. The central or two-track portion of the tunnel was constructed without any

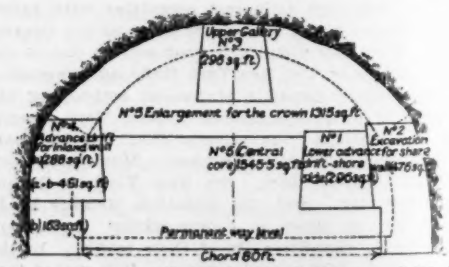

Fig. 2. Cross-Section Showing Sequence of Work in Conical Section of Genoa Tunnel.

great trouble by the standard Belgian method of construction. A cross-section of this portion is shown on Fig. 1, and explains clearly the character of the masonry work.

The manner of constructing the conical entrance section is indicated by Fig. 2. A side drift No. 1 was first driven and from it the wall portion No. 2 was taken out sidewise. The top heading No. 3 followed, and was succeeded by the bottom side

drift No. 4. Upon completion of the wall galleries the side wall masonry was laid. The bu lders then proceeded with the lateral enlargement of the top heading until portion No. 5 had been taken out. The roof arch was then built, and the core No. 6 was removed from within the completed lining. The chief feature of this work was the very heavy timbering and centering required to support the roof. The timbering and centers were both carried on the core section No. 6, which was left till the last for this purpose.

The method of excavating the union section joining the old and new tunnels is shown by F g. 3. As will be seen, a hole was cut through the haunch of the old tunnel lining and a transverse gallery carried across to the wall line of the enlarged structure. Along this wall line a gallery was driven forward and backward and the side wall built within it. The crown section was then taken out and the roof arch built. Heavy roof timbering was required in this section, and the old tunnel roof had to be strongly timbered to permit it to be torn away safely. This portion of the work was made additionally difficult by the necessity of not disturbing traffic on the line.

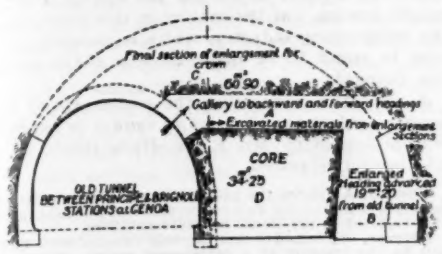

Fig. 3. Cross-Section Showing Method of Work in Joining Old and New Tunnels.

We are indebted to the London "Engineer" of Aug. 28, 1903, for the information from which this description has been prepared.

ANNUAL MEETING OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

The Society of Naval Architects and Marine Engineers, which maintains headquarters at 12 West 31st St., New York city, meets annually in that city for the discussion of professional papers. The eleventh meeting since the organization of the society in 1892 was held last week, on Thursday and Friday, November 19 and 20. The time of the meeting was wholly given up to technical work; four sessions were held, on the morning and afternoon of Thursday and Friday, respectively. After the adjournment of the meeting proper, on Friday evening, the society met at Delmonico's, Fifth Ave. and 44th St., New York, at a banquet, where toasts and speeches supplemented the technical work of the meeeting in effecting the "promotion of the art of shipbuilding, commercial and naval," as the society's constitution expresses it.

At the opening of the meeting, under the presidency of Mr. Clement A. Griscom, who has held the office of president ever since the organization of the society, the Council submitted a list of nominees for officers for the coming year. These nominees were unanimously elected; the new officers are as follows: President, Mr. F. T. Bowles; Vice-Presidents, Messrs. W. L. Capps, C. W. Rae, R. D. Evans and F. E. Kirby; Members of Council, Messrs. J. A. Linnard, W. H. Brownson, W. D. Forbes and C. R. Hanscom. At a later session, the Council accepted the resignation from the office of Secretary, of Mr. W. L. Capps, whose new duties as Chief of the Bureau of Construction and Repair, U. S. Navy, make it impossible for him to continue the work of the office. Mr. W. J. Baxter, Naval Constructor, U. S. Navy, was appointed Secretary and Treasurer in his place.

Professional Proceedings.

The professional work of the meeting was opened by Mr. E. A. Stevens (Hoboken, N. J.), with a paper entitled "Progressive Trials of the Ferryboat 'Bremen.'" The "Bremen" is a double-ended screw ferryboat, of about 850 tons displacement and about 1,800 HP. machinery. She reached about 12.9 knots on her trial. The same vessel had been tried in 1894, with an inferior set of screws. The two trials are compared by curves, and an estimated analysis of the resistance and losses is given. This division of power is given in the following table, with similar figures for two other Hudson River ferryboats:

	Bergen. HP.	%	Cincinnati. HP.	%	Bremen. HP.	%
Engine friction	115	16.4	124	12.9	175	18.5
Propeller losses	280	40	331	34.5	275	29
Race augm't of resist'ce	65	8.9	88	9.2	209	22.1
Skin-friction resistance	155	22.1	191	19.9	178	18.8
Wave-making resistance	95	13.6	226	23.5	113	11.9
Total I. H. P.	700	100%	960	100%	950	100%

In discussion it was suggested that with the present development of steam turbines these should be found of value for ferry service, and also that water-tube boilers might be more widely used. The more skilled care required by water-tube boilers was urged against them, on the ground that it was difficult to always have the proper skilled attendance, and that in ferry service reliability was a prime consideration. Col. Stevens, in reply, pointed to the 23d St. ferryboats of the Pennsylvania R. R., at New York city, which are fitted with water-tube boilers; no trouble is experienced there in securing proper care of the boilers. As to steam turbines, the low draft and great beam of ferryboats made it impracticable to use screws of fine pitch, large slip and high speed, as would be required by steam turbines. Their use in ferry service has been thoroughly discussed by builders of ferryboats, and has always been decided against.

Mr. R. C. Monteagle (Morris Heights, N. Y.) read a paper entitled "Notes on the Arrangement and Construction of Steam Pipes and Their Connections," referring of course to steam piping on ships. This paper is abstracted elsewhere. It points out that steam piping for pressures exceeding 150 lbs. should be made of steel and never of copper, and that certain details such as expansion joints and drainage require more care in design than is usually accorded.

In discussion, Mr. W. D. Forbes (Hoboken, N. J.) described two pipe connection details which he had found of great value, but which as he later found had been previously used elsewhere. The first of these is to make the thread on the end of pipe and the thread in the connection flange slightly different in pitch, say 11 and 11½ threads per inch, and then screw up tight, using fish-oil in the joint. This always secures a satisfactory tight joint. The face of flanges should be slightly dished and a wedge-shaped packing strip used, to secure tight connection without danger of packing projecting inside the pipe. The second detail referred to is a universal angle joint, which is in construction like a right-angle L cut on an angle of 45° and with a bolt or a union sleeve connecting the two halves. Any angle from straight to right angle is secured by adjusting this fitting; this avoids the necessity of making special fittings for the odd angles frequently occurring in ship piping. A new method of connecting tubes to flanges, flue-sheets, etc., was described by Mr. L. D. Lovekin (Camden, N. J.), who also recounted some high-pressure tests made on such connections. The method comprises grooving the inner bore of the flange or sheet with several shallow circumferential grooves, and expanding the tube into the hole with a specially-built expanding machine. Instead of beading the end of the pipe is flared out into a conical recess in the outer side of the flange or tube-sheet. When properly applied this method is stated to give many times the strength of a brazed flange-connection.

A paper on "Gasoline Engines for Marine Propulsion" was read by Mr. D. H. Cox (New York). The paper describes the application of gasoline engines to speed-launches, giving some recent examples of high-speed boats of this type: the "Adios," a 55-ft. boat fitted with a 120-HP. 6-cylinder engine, which has made a speed of 24 miles per hour; and the "Standard," a 58-ft. launch fitted with a 110-HP. 6-cylinder engine. The latter engine, with 8 × 10-in. cylinders, weighs 3,200 lbs., and makes 400 r. p. m. Several smaller boats are described. The author concludes with the following statement:

> The outlook for the continued increase in the use of the gasolene engine for marine work is, in my opinion, most promising, and more particularly in engines of considerable size. Up to the present, the lack of confidence in engines of this type has, for the most part, limited their use either to small launches or to vessels in which the power required was not great, and the installation of more than 100 HP. in one hull has been quite an unusual event.
>
> As an illustration of the saving in room effected it may be stated that in a 75-ft. steam launch of recent design, with water-tube boiler and four-cylinder triple-expansion engine of 175 HP., the total length of boat given up to engine and boiler room was 18 ft., the whole width of the boat as well over this length being taken up to provide for bunker space and auxiliaries. A 175-HP. gasolene engine would require only an engine room of 12 ft. × 5 ft., saving 6 ft. in length, and leaving considerable space available on each side of the engine room hatch. Owing to the absence of auxiliaries two engines of this size, or 350 HP., could be installed in this launch in the same 12 ft. of engine room. From the we ght point of view one 175-HP. gasolene engine would weigh about the same as the steam engine thus saving the weight of boiler, piping, auxiliaries, and feed water, as the coal may be offset by the oil carried, the total saving being about 15,000 lbs., or 30% of the total displacement. Even with 350 HP. there would st ll be a saving of about 10,000 lbs. over the weight of the 175-HP. steam engine.

In discussion, Mr. W. P. Stephens (Bayonne, N. J.) called the present a time of revolution in launch and motor-boat building, following the development of the gasoline engine for boat propulsion. The English still hold to the kerosene engine, but on continental Europe and in America the gasoline engine has found very wide and successful use, completely crowding out the naphtha-vapor engine. Alcohol motors promise to become important in the future. The statements of the author for the superiority of the gasoline engines over steam equipment found some opposition. One speaker stated that the steam yacht "Arrow" of New York has steam machinery which weighs only 17 lbs. per HP., including all the auxiliaries, even the electric lighting machinery. Another speaker reported that he had contemplated changing his 55 × 7½-ft. launch from steam to gasol ne. The boat has at present a 104-HP. triple-expansion engine and water-tube boilers. He found that an equivalent gasoline engine would cost to operate the value of four tons of coal per day of 10 hours, which was so high that the steam equipment was retained.

THE DESIGN OF STEAM YACHTS.

Mr. C. H. Crane (New York) presented in abstract a paper entitled "Some Thoughts on the Design of Modern Steam Yachts." The American steam yacht has developed from the English designs, which from the first were sea-going ships rather than harbor boats. On this side of the water greater engine power (for higher speed) and more luxurious fitting were demanded, and the problem has been to meet these requirements without making the vessel less roomy or less seaworthy than the English boats. Steam yachts are either ferryboats, to take the owner to and from his country place, or cruising vessels, for making long tours. The development in steam yacht building has been great in recent years. As many as 253 American-owned steam yachts, of 28,306 tons aggregate, have been built since 1890; this is over half the number at present registered in America. The plans of one of the most recent, the "Noma," are given in the paper to illustrate how the requirements for comfort, speed and seaworthiness have been met in a particular case. The vessel is 226 ft. on water line, 28½ ft. in breadth, and 18¼ ft. deep, with a trial displacement of 1,035 tons and a speed of 19 knots. The engine is a 4-cylinder, triple-expansion engine, running at 205 r. p. m., of 4,200 I. HP. Almy water-tube boilers are used. The vessel has large bilge keels "which apparently do not interfere with her speed." It is stated that 22% of the displacement, exclusive of coal, water and stores, is occupied by machinery, while 37½% is given up to outfit and joiner work.

The discussion turned partly on general design and partly on details of steam yachts. Mr. H. C. Sadler (Ann Arbor, Mich.) thought that the conventional form of steam yachts, as developed from that of sailing yachts, might profitably be modified by filling out the midship section and fining the after part, approximating to torpedo-boat design; this would give better speed. Mr. E. A. Stevens (Hoboken, N. J.) remarked on the typical forms given to stem and stern of yachts. The clipper bow, with bowsprit, is of no use, but is built because sailing vessels had it, and the stern is similarly derived. The speaker thought this a fad on the part of owners, and a false seeking after beauty; his own idea is that "something built to do certain work in a clean, workmanlike way

is more beautiful than something that appears a survival." Mr. Crane admitted that the shaping of the ends was purely a fashion, and as such was required by the owner; the extended stern has, however, an advantage in giving a larger quarter-deck. On the subject of bilge-keels, and the increase of resistance which the author imputed to them, Naval Constructor D. W. Taylor stated that trials in the model-basin at Washington had shown, that when properly fitted, bilge-keels have no effect on the resistance except the slight one due to the increased wetted surface. Moreover, two torpedo-boat destroyers of exactly similar design, but one with bilge-keels and the other without, were compared in their service results, and it was found that if there was any difference the boat with bilge-keels had a shade the better of it. Concerning full midship section and fine ends, Mr. Taylor reported that the model-basin tests show that this gives an advantage up to a certain speed, about 24-25 knots; beyond this point the shaping of the ends is of practically no influence. Screwed joints for boilers were mentioned in the paper, which reported upon them quite favorably. Several of the members seconded this favorable opinion, one of them with the statement that since 90% of the steam yachts in the country have water-tube boilers, nearly all of which are with screwed joints, no defence of this form of joint was necessary.

Besides those named, Messrs. A. A. Packard (Bristol, R. I), and E. E. Roberts (New York) discussed the paper.

WATERTIGHT BULKHEADS.

Commander Wm. Hovgaard, of the Royal Danish Navy, read in abstract a paper on "Watertight Subdivision of War Ships." This paper, an abstract of which we expect to present in a future issue, gives extended calculations on the loss of stability and the angle of heel resulting from flooding of variously-placed compartments in vessels. Certain conclusions are drawn as to how the compartments should be placed. In the more general discussion of the subject, the author recommends a double bottom up to the armor belt, wing passage bulkheads along the sides where possible, subdivision of engine and boiler rooms by transverse bulkheads whenever possible, and the division of the vessel into independent sections by a number of transverse bulkheads without doors below the water line.

Mr. T. Lucas (Brooklyn, N. Y.) claimed that the protected cruiser, which the author classed as an obsolete type, still has possibilities, particularly for small boats. The position of the protective deck should, however, be chosen with regard to maximum load conditions, i. e., placed higher than is customary. Mr. R. M. Thompson remarked that during last summer's manoeuvers of the British navy the protected cruisers were kept under the shelter of battleships as long as an armored vessel of the enemy was in sight, and appeared to be quite useless. Naval Constructor D. W. Taylor called attention to the fact that the most serious collisions of war vessels, for instance the "Camperdown"-"Victoria" collision, were at low speed, and that when a vessel rammed another at full speed it would go clean through the latter and both would go down. The greatest care in water-tight subdivision would not avail in that case. The plan of having transverse bulkheads without doors has been tried on the "Texas," but that vessel was in commission only a few months when the call from those in charge of her for doors through the bulkheads to enable the vessel to be worked became so urgent that the doors were put in; probably no more vessels will be built by this country without bulkhead doors. The case of the "Texas" was farther referred to by Mr. F. T. Bowles; subsequent to the introduction of the doors an injection pipe in the vessel broke, the ship was flooded, and because of the presence of the bulkhead doors the ship was sunk. On the strength of bulkheads, Mr. Bowles stated that bulkheads are now always tested, after building, under a water pressure greater than could be reached in an actual accident; the bulkhead must be absolutely tight under the test-pressure, and its deflection must be within the elastic limit. Such testing was not practiced at the time of the "Victoria" and the "Texas."

In reply to Mr. Taylor, Mr. Hovgaard stated that a number of French and German war vessels have as many as 10 or 12 transverse bulkheads without doors, and these vessels are operated successfully. On the question of protected cruisers, he conceded that this type would always be adopted, necessarily, for small vessels.

"Non-Corrosive Nickel-Steel Boiler Tubes," by Mr. A. L. Colby, was next discussed. The paper, which we reprint on another page, was read in abstract by the author, who also showed a number of speciments of tubes and test-pieces of both mild carbon steel and nickel steel, after various tests such as bending, flattening, expanding and beading, etc. In the discussion on the paper, the value of saving weight, particularly in torpedo-boats and destroyers, was generally conceded, and the decreased risk of breakdown secured by nickel-steel, boiler tubes was stated to represent a value to be deducted from the excess cost of these tubes. It was also claimed that the absence of pitting and roughening of the tube surface would reduce the adhesion of oil and scale. One member expressed some doubt whether cold bending of nickel-steel tubes would increase their rate of corrosion, since such an effect is often observed in ordinary steel tubes. Mr. Colby replied by stating that the Gardner-Serpollet automobile flash-boilers were now made of nickel-steel tubing; these boilers require an extreme amount of bending of the tubes, yet since the adoption of nickel steel as tube material no trouble from corrosion had been experienced.

The final paper of Thursday's sessions was entitled "Curves of Form of the Initial Condition," and was read by the author, Mr. G. C. Cook (New York). The paper gives analytical and other methods for computing the principal functions of a vessel's form which may be recorded in curve form for comparative purposes. Curve-sheets for different vessels are given.

THE METRIC SYSTEM AGAIN.

Naval Constructor J. H. Linnard (Washington, D. C.) read a paper entitled "The Metric System in Relation to the Shipbuilding Industry of the United States." The paper draws attention to the fact that the bill introduced before Congress, to establish the metric system as the legal standard of measurement in the United States, would first of all compel all the government shipbuilding to be done to metric dimensions. This would introduce great confusion into the shipbuilding industry, even so far as to force the yards that take government contracts to confine themselves exclusively to government work. A number of arguments against the metric system per se are combined with the argument against putting the whole burden of inaugurating the change upon the shipbuilding industry. The paper refers to the reintroduction of the metric system bill at the present session of Congress, and concludes as follows:

> There is one notable exception to the use of the metric system contained in the bill quoted, and that is the survey of the public lands. If the metric measurements are desirable in the United States, why make this exception? There are good reasons for the exception, the same good reasons as exist for the rejection of the whole bill. Are you willing to let the agitation for its adoption go on without making your sentiments known to the legislative authorities?

Considerable time was spent in discussing this paper. Mr. F. A. Halsey pointed out a number of serious errors in the usual pro-metric arguments. The first and principal of these is in the statement that two-thirds of the world, a total of 436,000,000 people, is using the metric system. This is radically untrue. The cases of China, Japan and Turkey, usually placed on the "metric" list, were cited as instances of errors in the list, and proof was given that these countries are thoroughly non-metric. Cuba and the Philippines were similarly treated. Mexico is in nearly the same case; a striking instance is the lumber trade there, in which lumber is made and sold by inches and M-feet, and only in billing is the word square meters substituted. The argument of the universality of use of the metric system should be just reversed: "After 100 years of legislative coddling, the striking thing is the littleness of its use." The recent adoption of inch-standards for pipe, as the only standards of size, by the Society of German Engineers, and the demand by certain French interests for legislative compulsion to introduce the metric system in the French textile industries were instanced to show the impracticability of the metric system.

Mr. W. M. McFarland (Pittsburg, Pa.) reported that he had been called before the House committee to testify regarding the effect of the metric system on the work of his company (Westinghouse Electric & Mfg. Co.). Estimates had been made by that company of the cost of changing to the metric system. The changing over of the shops would cost half a million, and changing the drawings would cost another quarter million. He had been unable to make the committee, composed largely of lawyers, understand the value of convenient round numbers in industrial work. Mr. W. D. Forbes put in a plea for the metric system, saying that we will not live forever and should work for succeeding generations. Prof. C. H. Peabody, without discussing the merits of the metric system, put the matter in this light: Shall the shipbuilding industry, which is probably less able to stand it, be made to bear the brunt of the change?

A resolution expressing the sentiments of the society against the adoption of the bill in question was presented by Mr. E. W. Hyde (Bath, Me.). The resolution reads:

> Whereas, A bill for the adoption of the metric system in the departments of the Federal government has been favorably reported to the House of Representatives,
> Whereas, We consider that the only effect of such a law will be the creation of a government metric system and the continuation of the existing system in ordinary commerce and industry,
> Whereas, The confusion resulting from a dual system of measurements would be intolerable,
> Whereas, We believe the adoption of the metric system of weights and measures by the people at large to be impracticable; therefore be it
> Resolved, By the Society of Naval Architects and Marine Engineers, assembled in annual meeting, that we condemn all legislation intended to promote the adoption of the metric system in this country;
> Resolved, That we especially condemn the bill which was reported to the last House of Representatives as one which can do nothing but introduce confusion where we now have uniformity.

The resolution was carried by a vote of 40 to 11.

A paper on "Electricity in Manufacturing Plants" was presented by Mr. W. M. McFarland (Pittsburg, Pa.). It describes the extension of motor driving and discusses some of the particular points arising in applying electric power to shops —group driving, speed control, etc. Many illustrations of electrically-driven tools are shown. The discussion of the paper brought out no material matters, and we pass it without further notice.

Mr. Charles R. Hanscom described at some length "The Design and Building of the 21,000-ton Steamships "Minnesota" and "Dakota." The vessels in question are the largest yet built in the United States. Their construction is the more interesting because when they were begun there was no yard existing at the place of building; the shipyard (of the Eastern Shipbuilding Co., New London, Conn.) was developed as the ships were built. We hope to present this paper in a future issue. The paper was discussed by Messrs. Stanbury, Newman, Patterson, Main, and others. Mr. Newman called attention to two vessels recently built by the New York Shipbuilding Co., at Camden, N. J., the "Mongolia" and the "Manchuria," which are only slightly smaller than those described in the paper. In driving large rivets, 1¼-in., that company has used the expedient of countersinking the rivet hole under the head, and using a round or snap head over this, thereby giving a stronger rivet-head. It was pointed out by another speaker that this style of riveting had been previously used at Cramps', the reason for its use being the importance of closing up the plates and getting a sound head. Some points in the construction of the vessels described in the paper, notably the longitudinal framing, were commented upon.

Naval Constructor D. W. Taylor (Washington, D. C.) presented a paper on "Ships Forms Derived by Formulæ," which was read in abstract by Mr. J. H. Linnard. The paper deduces a number of formulas which may be used to derive the curves of the various sections for given dimensions and displacement. They enable the form to be varied slightly in any desired manner without changing the dimensions or displacement, by assuming different values for the constants. They have been used in the work of the model-basin at Washington, in altering model forms for successive improvement on the basis of test results.

In discussion, Mr. W. Hovgaard emphasized the value of experimental tanks. Many of these are now in existence, and their number is rapidly in-

creasing. To analyze and coördinate the results of tank tests, formulas like those presented are almost essential. The model tanks are, however, nearly all of them built and run privately, either for naval purposes or for the purposes of a commercial shipping concern, and the results obtained are kept secret. To make them of real value, they should be open to scientific experiments, or better, the results obtained should be utilized for the public benefit by publishing them.

On a question by Mr. G. C. Cook as to whether the tank at Washington will test models for private parties, Mr. Linnard replied that this is regulated by the Act of Congress establishing the tank; any person may submit a set of lines for test, and the department will make a model to these lines and test the model, supplying as results a curve of horse-power required for the propulsion of the vessel in question at different speeds. It is required that a deposit be made, sufficient to cover the probable cost of the work. According to Col. E. A. Stevens, who recently had two models tested, the cost for the two tests was $350; a deposit of $500 had been required.

A paper entitled "A Graphic Method for the Calculation of the Stability of Ships," by Mr. M. H. Bauer (Berlin, Germany) was read by title. There was no discussion of the paper.

Prof. W. S. Leland (Boston, Mass.) read a paper on "Displacement and Stability Calculations by Improved Methods." These calculations, which are extremely tedious and slow, are here arranged in a new manner, and the computations ordered so as to require a minimum of labor. The time required for the work can by this method be reduced to a third or a fourth of the time required by the usual methods. Mr. A. M. Main (New London, Conn.) stated in discussion that he had seen a closely similar method of calculation used on the Clyde some 14 years ago.

A paper on "Launching of the Cruiser 'Chattanooga,'" by Mr. M. S. Chase (Elizabeth, N. J.) was read in abstract. The launching described was made difficult by the fact that after launching the vessel required to be brought to rest in a length of 283 ft., due to the narrow water space available. This was accomplished by the use of a "mask" or timber shield at the stern of the vessel, whose resistance in the water checked the speed, and the use of rope stops, attached to ground chains on the line of launching and to the vessel, the stops being arranged to be broken by tension successively as the vessel passed. The momentum of the ship, to be absorbed by the stops, was calculated on the assumption that the mask was of no effect. Tests on 7-in. manila rope were made to give its strength and its ultimate elongation, to find the work absorbed per foot of length. Fifty stops on each side, 100 in all, each 20 ft. long, were provided. Only 53 of these were broken, showing that the mask had considerable effect; its area was 93 sq. ft.

"Notes on Side Launchings," by Asst. Naval Constructor W. G. Groesbeck (Richmond, Va.) presented a report of the launching of the cruiser "Galveston" and the dredge "Benyuard." The arrangement used, which is fully shown by drawings in the paper, was more elaborate than is usual on the Great Lakes, where this method of launching is almost universal.

Mr. W. A. Fairburn (New London, Conn.) presented a paper on "Launching of Large Merchant Vessels." This was in the main a collection of launching data of a large number of large-size merchant vessels. Some discussion of various factors affecting the operation of launching was added. The discussion touched only on minor matters, and need not here be recorded.

The closing paper of the meeting was "Some Notes on the Performance of the Torpedo Vessels of the United States Navy at Sea," by Lt. L. H. Chandler, U. S. N. This paper is purely a record of the movements and conditions of operation of the torpedo-boat and destroyer flotillas of the U. S. Navy during the past year. It is expected that these will be supplemented later by records of the run to the Asiatic station.

In the course of the meeting, Mr. Lewis Nixon called attention to the important losses by death which the society and the shipbuilding industry have sustained during the past year—including names like those of I. M. Scott, W. R. Trigg, H. G. Morse, Henry Steers, and others—and on his motion the society passed a resolution of condolence and sympathy to the relatives of the deceased.

AN APPARATUS FOR MEASURING GAS LEAKAGE.

By Emil Guarini.*

Little or nothing has been done in the past to detect and measure the leakage of illuminating gas from street mains. In consequence, most gas-piping systems are in an indifferent state of repair, and leaky joints may be said to be the rule rather than the exception. The actual cost of the gas thus lost from the pipes is not inconsiderable, and would in many cases warrant careful leakage surveys and subsequent repair of the pipes, to cut down this waste to a minimum. More important, however, is the constant menace of accident and of damage to public health, which lies in the existence of accumulations of gas in the ground and in hollows such as sewers, manholes and wire conduits. Explosions resulting from such collection of quantities of gas are of frequent occurrence; it is not uncommon, either, to read of workmen overcome by gas, often with fatal results, when entering manholes or street excavations for access to buried wires or pipes.

That so little attention has been given to gas leakages on the part of gas companies is due largely to the fact that no means were available for detecting and measuring the loss of gas. Soundings made at intervals along the line of the pipes, using chloride of palladium, have sometimes been employed to locate the more important leaks. Indicators utilizing the principle of osmotic diffusion of gas through porous membranes have also been used for this purpose. The prime fault of these methods is that they give no knowledge of the relative magnitude of the amounts of gas indicated, so that they do not show, for example, whether there is a sensible leak at or near the sounding, or whether there is merely a certain amount of gas held in the soil.

A new method exploited by the Compagnie pour la Fabrication des Compteurs et Matérial d'Usines à Gaz, of Paris, France, avoids the disadvantages incident to the use of the previous methods and

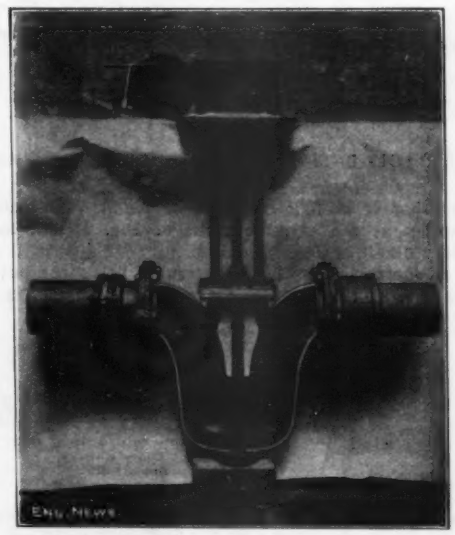

Fig. 1. Isolating Trap for Testing Leakage of Gas Mains.

makes possible a periodic leakage survey by districts to check the condition of the system. The method is very simple: a section of main is isolated from the system; all services on this section are shut off, and by means of a small portable gasometer a constant pressure of gas is put on the isolated section. The speed with which the gasometer descends will then directly indicate the rate of leakage from the main, at the pressure used for the test.

To enable any section of main to be readily isolated, and at the same time to offer convenient connections for the testing gasometer, a water trap constructed as shown in Fig. 1, is built into the main at the desired section intervals. It is a U-shaped trap, provided with three connection pipes leading to a small surface box in the pavement above. The central pipe serves to introduce and pump out the water used to seal the trap, while the two outer pipes carry the gas to and from the gasometer. Suitable caps and cocks are provided in the surface box. When it is desired to isolate any section of main between two of these traps, the latter are filled with water, through the middle pipe, to a point well above the central partition; the two outside pipes are then connected to the portable gasometer, which may be filled under regular service pressure through the pipe on the supply side of the trap and then connected to the isolated section by the other pipe. By suitably loading the gasometer the discharging pressure may be brought to the desired standard (100 mm. of water) for the test.

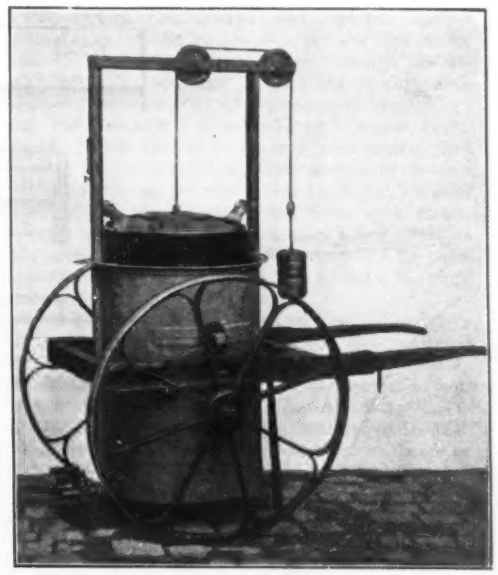

Fig. 2. Portable Gasometer.

The portable gasometer is shown in Fig. 2. The bell rests in an annular water pocket formed by the lower tank. Two pipes fitted with stop-cocks (shown at the left hand bottom of the tank) serve to make the gas connections with the surface box of the isolating trap. The gasometer shown in the view has a capacity of 300 liters of gas, which, if the service pressure be 25 mm. (1 in.) and the test pressure 100 mm. (4 ins.) of water, can raise to the test pressure a length of main containing as much as 1,400 cu. ft., say a 12-in. pipe 1,800 ft. long.

In testing the gas leakage in any section of main it is necessary, of course, that the house services or branches be closed during the test. However, as the test is made very rapidly, the stoppage of supply need not exceed say an hour. After the amount of leakage for any section is determined by this apparatus, soundings may be made by the chloride of palladium method to locate the individual leaks. Repeating the test with the gasometer apparatus after repairs are completed on any section will serve to show what degree of improvement has been secured.

The expense of installing the section isolating traps and making the leakage tests is in most cases soon paid for out of the saving in gas. For example, one system of piping was fitted with 25 traps, at a cost of $400, and tests and repairs were made by their means at an additional cost of $1,200. The reduction of leakage amounted to 3,200,000 cu. ft. of gas per year, which would just pay for the expense if the gas cost 50 cents per 1,000 cu. ft. At the Paris gas works, where this apparatus has also been used, the reduction of leakage amounted, at the various stations, to from 550 to 700 cu. ft. of gas per ton of coal distilled; in Station No. 4 of the same works the leakage loss has been reduced to 6.1% of the total product.

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CHANGES IN THE SETTLING BASINS AND THE NEW HYDRAULIC DREDGE OF THE ST. LOUIS WATER-WORKS.

By E. E. Wall.*

Some interesting changes are now being made in the settling basins of the St. Louis Water-Works. In brief, they are designed to substitute continuous sedimentation for the fill and draw method. This involves substituting a long receiving and quieting chamber for the present filling conduit, converting the division walls into weirs, building a by-pass conduit, and connecting the several basins with this conduit by means of siphons.

The present settling basins at the Chain of Rocks were put in use some ten years ago, and superseded the original basins at Bissell's Point, nearer the city. The more recent basins are six in number, and were described and fully illustrated in Engineering News of April 18, 1891. Each basin is 400 x 670 ft. in plan (Fig. 1), and has a sloping bottom located some 14 to 16 ft. from the top of the coping of the side walls. Earth banks, with retaining walls, the whole aggregating about 40 ft. in width, divided the basins into three pairs, and each basin of a pair was separated by a wall 7½ ft. thick. In the changes now in progress the tops of these old banks and walls are being converted into weirs.

It is expected that the weirs (see Figs. 1 and 2) will thoroughly aerate the water, since the vitrified brick placed on end are staggered for the purpose of leaving an air space between the brick and the water.

Under the old method each basin was supplied with river water from a filling conduit parallel with the ends of the basins farthest from the river, and emptied, after sedimentation, into a drawing conduit at the opposite ends of the basins. The method now proposed contemplates a uniform flow of water through all six basins, and the weirs are being built nearly to the full length of the division walls. This necessitates a change in the direction of the filling water, which is to be effected by the long and narrow receiving and quieting or stilling chamber, shown in plan and section at the extreme right of Fig. 1, and in more detail by Figs. 3 and 4.

A short length of 7-ft. circular brick conduit leads from the old filling conduit, shown in Fig. 1, to a right-angled turn in an extension of the receiving chamber, Figs. 1 and 2. Progressing towards the center, in length, of the receiving chamber, it changes in cross-section, as shown by sections DD, CC and EE, Fig. 4; the latter is typical of the chamber proper, which, it will be seen, has a covered bottom and sides, of concrete-steel construction. A longitudinal wall, at one side of the center, and pierced at its bottom with passages 3 ins. high and 2 ft. long, 3 ft. c. to c., changes the direction of the incoming current of water and is designed to insure a uniform flow over the preliminary weir. This weir, it will be seen, is somewhat shorter than those between the several basins. The receiving chamber is designed to be self-cleansing, and its sectional shape was determined by a series of experiments with very muddy water.

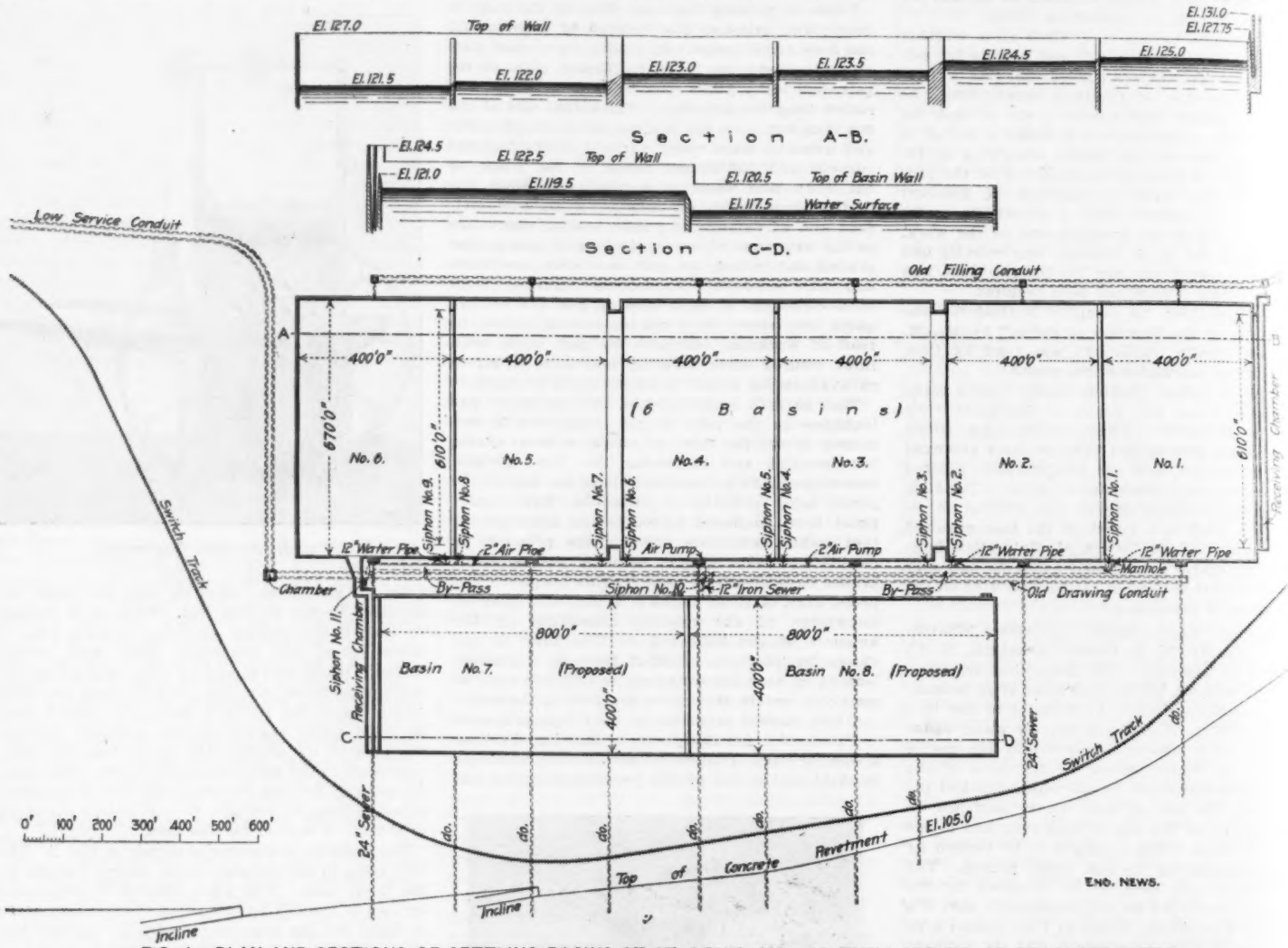
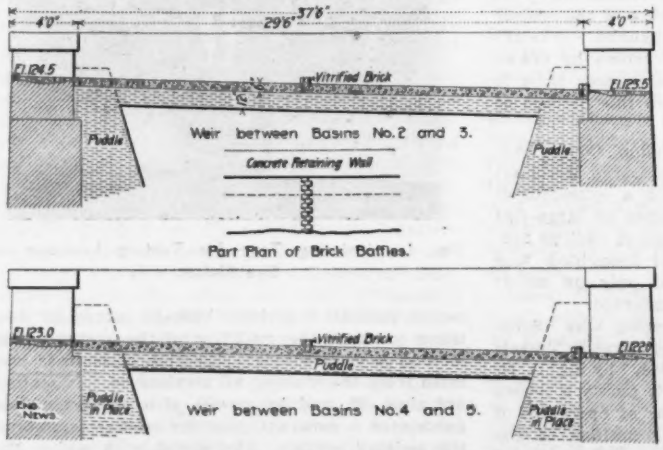


FIG. 1. PLAN AND SECTIONS OF SETTLING BASINS AT ST. LOUIS, MO., AS THEY ARE TO BE RECONSTRUCTED.



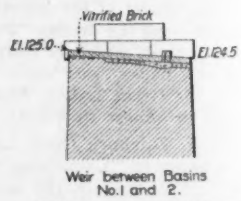


FIG. 2. SECTIONS OF WIDE AND NARROW WEIRS.

The mud settling on the 15-ft. side of the by-pass will be washed down the slope, which is approximately a cycloid, through the opening in the middle wall, up the slope on the 10-ft. side of the by-pass, approximately a parabola, and over the weir into Basin No. 1, by the cross-current through the openings in the middle wall.

It is expected that the greater part of the work of sedimentation will be accomplished by Basins 1 and 2, which will be cleaned by means of hydraulic dredges.

The hydraulic dredge built by the department

*Principal Assistant Engineer, Water-Works Extension, St. Louis, Mo.

has been in operation for experimental purposes for about three months. With it, a basin can be cleaned while in regular service.

A centrifugal pump, electrically-driven, is mounted upon a floating barge and is provided with a suction pipe which extends to the bottom of the basin, and also with a flexible floating discharge pipe, which is connected by a 12-in. iron pipe at the bottom of the basin, with the sewer draining the basin.

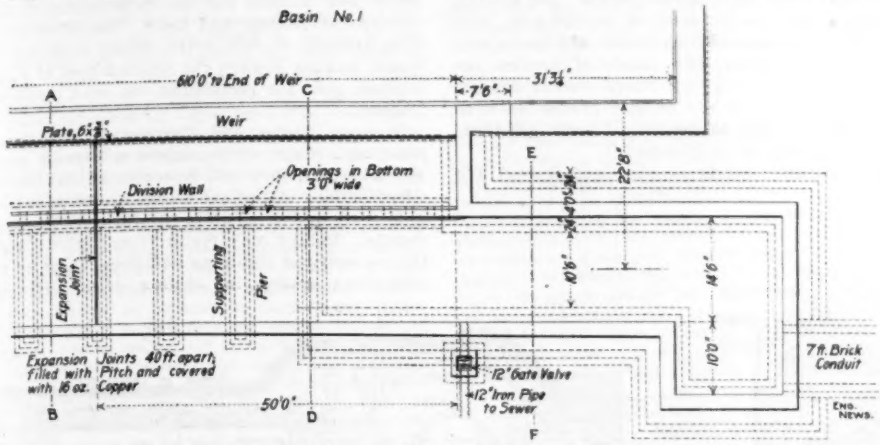


FIG. 3. PLAN OF UPPER END OF RECEIVING CHAMBER.

The barge is 16 × 21 ft., × 3¾ ft. deep, and has a draft of about 26 ins. It is provided with a deck house and is propelled across the basin by an electric motor, operating upon a stationary rope stretched for that purpose.

The main pump is a 12-in., Morris side suction centrifugal sand pump, direct-connected to a 90-HP. shunt-wound C. & C. motor. Its capacity is 348 cu. yds. of sediment per hour. There is also a jet pump which furnishes 450 gallons of water per minute at a head of 75 ft., to a series of 13 jets at the mouth of the suction pipe for dislodging the mud. This jet pump is a 4-in. Morris double suction centrifugal pump, direct-connected to a 20-HP., shunt-wound, C. & C. motor.

The suction pipe of the main pump is 12 ins. in diameter and expands at its lower end into a flaring or fan-shaped mouth-piece, having an opening 10 ft. wide and 1 in. high. This pipe is provided with rollers which rest on the concrete bottom.

The electric current used is taken from the direct-current, 500-volt circuit of the water-works railway, and is led to the dredge through cables supported by the floating pipe.

The floating discharge pipe consists of 21 sections, each 21½ ft. long, connected by rubber hose 3½ ft. long. The discharge pipe proper is 14 ins. in diameter, and is supported by two floating air-pipes, 12 ins. in diameter, one on each side.

The propelling rope is stretched across the basin a distance of about 680 ft., and the ends are connected to a trolley which is moved along on an I-beam, fastened by brackets to the basin wall. After a cut is taken across the basin, the trolley is moved 10 ft. (the width of the suction mouth) for the next cut. To prevent too great sag in the rope, it is supported every 50 ft. by floats. The propelling motor is a C. & C. double commutator, compound-wound, reversing, having 24 speeds, ranging from 85 to 520 revs. per min.

The basin is cleaned by halves, the discharge emptying on the side opposite the half being cleaned. As each half is cleaned, the discharge will be changed to the other side.

The by-pass conduit is of concrete, reinforced with corrugated steel bars, with a longitudinal division wall forming two compartments 7 ft. wide. The depth increases from 3 ft. at the upper to 6 ft. at the lower end. At each pair of siphons the two compartments of the by-pass conduit are connected by three openings.

The siphons, shown in plan by Fig. 1, and in detail by Fig. 6, connect the several basins with the by-pass conduit, and with the latter afford a means for cutting out any basin for cleaning.

When cleaning by hand, the by-pass will be filled by the 12-in. pipes from Basins Nos. 1, 2 and 6. The air will then be exhausted from the siphons at the ends of the basins nearest the one to be cleaned, thus establishing a flow through the siphon into the by-pass, around the basin being cleaned and out of the by-pass through the siphon, into the basin the other side of the one being cleaned. This system does away with gates. The siphons are connected so that any pair or any single siphon can be used. For instance: To pass Basin No. 3, the by-pass being filled with water, exhaust the air from siphons Nos. 2 and 5. This will give a flow through siphons into the by-pass, around Basin No. 3, out of the by-pass through siphon No. 5, into Basin No. 4.

The six present basins have an average capacity of 28,000,000 gallons each, and the two projected basins (shown by dotted lines, Fig. 1), of 36,000,000 gallons each. Allowing for basins out of service, all the remodeled system of sedimentation is designed for a maximum daily capacity of 160,000,000 gallons. The present consumption varies from 50,000,000 to 90,000,000 gallons per day.

Mr. Ben. C. Adkins is Water Commissioner of St. Louis, and the author of this article is in charge of the work described. The work of construction was begun on Aug. 1, 1903, and it is expected that it will be sufficiently near completion to permit the remodeled system to be put in operation about Dec. 1, 1903.

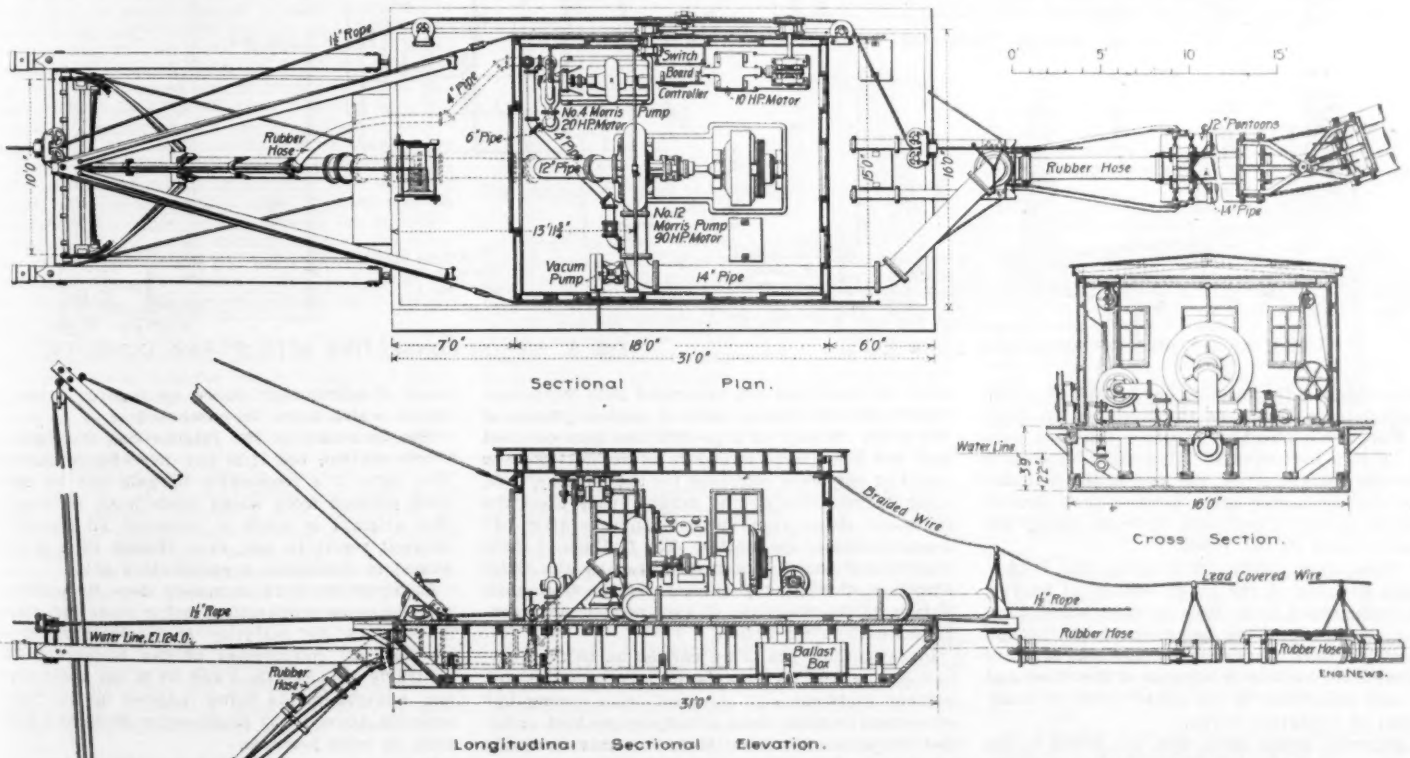


FIG. 5. HYDRAULIC DREDGE FOR CLEANING ST. LOUIS SETTLING BASINS.

THE UNITED STATES RECLAMATION SERVICE IN THE ARID WEST.*

By F. H. Newell,† M. Am. Soc. C. E.

On June 17, 1902, President Roosevelt signed the bill setting aside the proceeds from the disposal of public lands in the 13 Western States and three Territories. The fund thus created can be used for the survey, examination and construction of works for the reclamation of arid land. The amount in the U. S. Treasury is now estimated to be about $16,000,000. This is to be expended by the Secretary of the Interior and upon him is placed the entire responsibility of initiating and

*A statement contributed at the request of this journal.
†Chief Engineer, Reclamation Service, Washington, D. C.

carrying forward the great work of reclaiming the arid lands and making possible their settlement.

The law is very general in its terms and much is left to executive discretion, so that with good administration great results should follow. Certain important safeguards are provided by which the settlement in small tracts will be insured, and also the refunding to the Treasury of the amount of the investment, so that the money can be used over and over again. It is to be noted that the money comes originally from the West, is invested there, and the amount of the investment secured for return to the Government, so that taxpayers of the East do not, directly or indirectly, contribute to the development of the West excepting in so far as they may have in the past contributed to the acquisition of the West as a whole.

In order to carry into effect the terms of the law the Secretary of the Interior has organized an engineering force known as the Reclamation Service. For administrative purposes this has been built up as a portion of the Hydrographic Branch of the Geological Survey, the men in this Division of the Survey having spent most of their lives in the investigation of problems of water supply and of reclamation of the West.

To these men, originally forming the Hydrographic Division of the U. S. Geological Survey, have been added from time to time other competent engineers, these being obtained through competitive Civil Service examination. Most of these men are natives or citizens of the West and have had experience in the construction or management of irrigation works.

As necessity arises other men are added to the organization, examinations being held at short intervals, and a large register of eligibles established. It is the desire and intention to obtain the best men available for such work and preserve a high standard of proficiency by advancing men from one grade to another as they demonstrate ability.

The Hydrographer in charge of the Hydrographic Branch of the Geological Survey has been designated as Chief Engineer of the Reclamation Service. He is assisted by a staff of consulting and supervising engineers, and by specialists in various lines, such as electrical development and concrete construction. The field work is divided into districts, each in charge of an experienced engineer, who reports directly to the Chief Engineer. As a rule, each State and Territory is considered as a district, although the theoretical basis is one of drainage basins. In some States there are two or more districts, according to the prominent river systems.

The consulting engineers are elderly men of broad experience in hydraulic work. The district engineers are mostly men of middle age, who have shown considerable executive ability as well as engineering skill. The chiefs of parties are usually young men a few years out of college, while the assistants are college graduates with education sufficient to permit of their advancement as experience is obtained.

The consulting engineers visit and inspect the work in hand and are organized into temporary boards for the consideration of various phases of the work. Whenever a project has been outlined and the costs ascertained it is submitted to a board of engineers convened for the purpose, who, after examination on the ground, pass upon the facts and either approve or disapprove after full consideration of the matter. The findings of these engineering boards are transmitted by the Chief Engineer, through the Director of the Geological Survey to the Secretary of the Interior, with recommendations for action.

Investigations are being carried on in the various States and Territories to ascertain the important problems and to select from among the numerous projects those which appear best under the terms of the law. Many matters must be taken into account, not only of the physical conditions, but also of the legal phases and probability of ultimate success. The Reclamation fund must be carefully guarded from loss or diminution and the feasibility of every project considered from this standpoint.

Out of the almost innumerable needs of the arid lands, certain projects must be selected by the Chief Engineer and his advisers in nearly every State and Territory from the two or three, or more, projects which may be considered of national importance, and out of these one must be chosen for recommendation to the Secretary of the Interior for construction. There is thus opportunity for wide differences of opinion, and large responsibilities are thrown upon the men making these recommendations.

In two localities construction has already been begun. One is in Nevada, where a large canal is being built to carry the waters of the Truckee River to the Lower Carson reservoir site, where they will be mingled with the waters of Carson River and utilized for the reclamation of lands around Carson Sink and Lake. The other locality is in Arizona, on Salt River, where work has been begun looking toward the construction of a large storage dam for reclaiming the arid lands near Phoenix.

In other States and Territories projects are reaching a stage where, unless unforeseen contingencies occur, they will be recommended for early construction. All of the works are on a considerable scale and necessitate careful consideration of details. Delays may result from various causes; the necessity of obtaining additional facts, or from difficulties arising in dealing with individuals upon a satisfactory basis, as regards lands or rights which must be purchased.

The Secretary of the Interior has the right of condemnation, but it is not desirable to exercise this right if a reasonable bargain can be made with persons from whom lands must be bought. The attempt is made to complete all purchases without resort to law, even though time is consumed in arranging a satisfactory price.

Construction work is mainly done by contract, in some cases preparations being made for letting a contract by carrying on preliminary work through the employment of day laborers. The contracts are advertised and let in the usual manner, advertisements being inserted in the "Government Advertiser," Engineering News and technical or local journals.

It may be many years before the strength or weakness of the law or its administration are made manifest, as the reclamation of arid lands and the settlement upon them of prosperous families is not a thing which can be brought about in a short time. Every effort is being made to guard against mistakes and produce the greatest possible benefit to the country through the utilization of the resources which cannot be developed by ordinary means, but which when utilized will add to the strength and continued prosperity of the commonwealth.

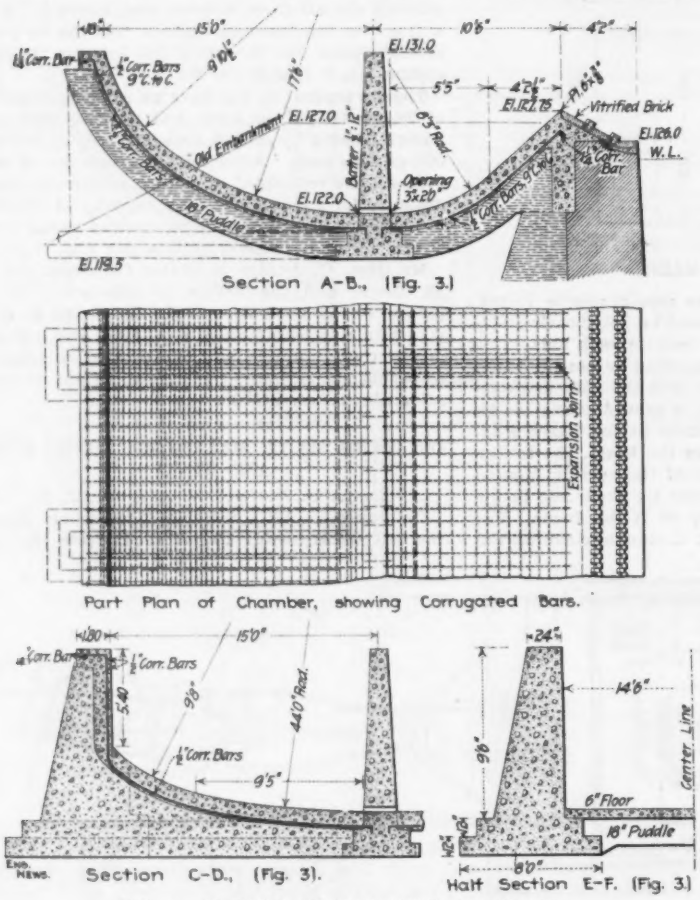


FIG. 4. DETAILS OF RECEIVING CHAMBER.

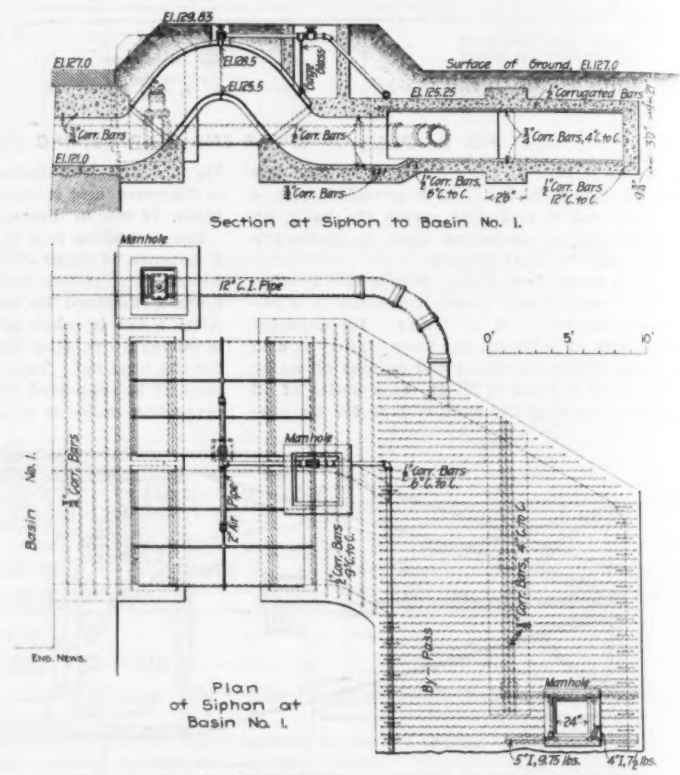


FIG. 6. SIPHON CONNECTING WITH BY-PASS CONDUITS.

NOTES ON THE ARRANGEMENT AND CONSTRUCTION OF STEAM PIPES AND THEIR CONNECTIONS.*

By Robert C. Monteagle,† M. Soc. N. A. & M. E.

The causes of failure in steam pipes may be classified as follows: First, faulty design; second, bad workmanship, and third, defective material. One of the forms of faulty design is in the employment of copper for pressures exceeding, say, 150 lbs. per sq. in. Owing to the number of accidents occurring with copper steam pipes, this material is being used less frequently in each succeeding year. The elastic limit of good sheet copper is reached at from 5,300 to 5,600 lbs. per sq. in., and the ultimate tensile strength about 30,000 lbs. per sq. in. In good steel pipe the elastic limit reaches from 30,000 to 35,000 lbs. per sq. in., and the tensile strength 53,000 to 60,000 lbs. per sq. in. These figures alone demonstrate the hopeless inferiority of copper for use in steam pipes as against steel. It may be accepted as a fact also, that copper in the vicinity of brazing is more or less injured by the heating, and in some cases by the overheating, which they are subjected to, yet where copper steam pipes, say 6 ins. in diameter and over, are used, the best practice is to "make them up." My reasons for so stating are that solid drawn copper piping of such diameter and the necessary thickness required is almost invariably of a non-uniform thickness, and frequently possesses the undesirable characteristic or tendency to split longitudinally. This characteristic, it may be noted, seldom develops at the original time of testing, and hence its extreme danger.

On the other hand, brazed copper piping never can possess the same strength as the original sheet from which it was made, even granting that the workmanship is exceptionally good. Rules are given for determining the thickness of copper to be used in steam pipes, in the pamphlet issued by the Board of Supervising Inspectors of Steam Vessels, but which do not state that such thickness should be increased where bends occur. Almost any engineer is familiar with this requirement, but unfortunately there are individuals who deem it good practice to elude their duty when presented in this or other similar form. It is, therefore, important that this requirement be embodied in the said rules. A better rule would be to prohibit the use of copper for steam pipes which are subjected to pressures exceeding, say, 150 lbs. per sq. in., and which exceed, say, 3 ins. in diameter.

A glaring error which has been perpetuated from one edition to another in this pamphlet is where this phrase occurs: "The flanges of all copper steam pipes over 3 ins. in diameter shall be made of bronze or brass composition, shall be securely brazed to pipe," etc. This of course should read "brazing metal."

Another form of faulty design is frequently found in the method of allowance for expansion. The ordinary expansion joint has the drawback of being unbalanced, and therefore must be furnished with "preventer bolts" so that the sleeve may not be forced out of place by the unbalanced pressure. The adjustment of these bolts must be accurately made, or an undue strain will be brought on the piping, either when steam is turned on or when the piping is cold. Another method is a simple dependence on the flexibility of the piping itself to take up the expansion. With piping, say, 3 ins. in diameter and over, this is not good practice, as the metal will become crystallized after constant working, and is liable to crack or break at the most rigid point. This class of accidents has in various cases been fatal.

Another form of faulty design, and a common one, is in the formation of depressions; however slight, in the piping, or, in other words, dropping from one plane to a lower, and rising to the original plane again. When steam is turned on the body of water which has collected in this depression is set in motion, and carried to the engine where damage is done, or excessive strains set up. In any case, separators of ample capacity should be placed near the engine, so that they may collect any water in the pipes. An efficient separator is very desirable, as the entrainment of water by steam traveling at high velocities is always a source of anxiety to engineers. It is absolutely certain that after entrainment of water takes place, no possible arrangement of piping can be made to carry such water back to the boiler without the intervention of an efficient separator. A method which will somewhat mitigate this evil is to superheat the steam as it leaves the boiler, and should the quantities of water carried over not be too great, this will possibly obviate the trouble. Objections to superheated steam are, however, great enough to rule this method out with the majority of engineers.

The second division, as classified, of the causes of failure of steam pipes is bad workmanship. This may be subdivided again into bad workmanship at the mill, and bad workmanship by the coppersmith or pipe-fitter who puts the piping in place. Bad workmanship at the mill is beyond the control of the users of steam pipe, whether that pipe be made of copper or of steel, and the following remarks are equally applicable to the manufacture of both kinds of pipe. It is nothing short of criminal on the part of the manufacturer of piping to neglect taking all the the precautions possible to inspect the material before, during, and after the process of manufacture. Possibly this is done, but I regret to state that such is not my belief. On the contrary, my belief is that inspection at the mill is not rigid enough, and that is why we have some of our failures of steam pipes.

The builder of a steam vessel, who installs all machinery, makes all connections, etc., is held responcible for this machinery, piping, etc., until the vessel is delivered, and frequently for a much longer time. Should any part of the piping fail, possibly causing loss of life, the builder is held responsible. Does this not seem unjust? Providing that the fault be in defective piping, the onus of blame should be placed on the manufacturer of the pipe, and he should be obliged to pay for the damage done. This method, if enforced, would undoubtedly have the desired effect of better inspection at the mill and the production of better piping.

Regarding bad workmanship by the coppersmith, it has been my observation that the greatest number of cases of bad workmanship in copper piping are directly connected with the brazing of flanges to pipes. The copper is frequently injured by excessive heating. To what extent the tensile strength of the copper is lessened by such bad workmanship it is very difficult to ascertain, but when such cases are discovered, however slight the burn, it is imperative to condemn the work. The heavier copper piping is, the greater danger there is from "burning" during the process of brazing joints, and hence further danger in its use for high steam pressures. The fitting of steam pipes of all kinds is a very important matter. Through the careless work, or bad judgment of pipe-fitters, strains

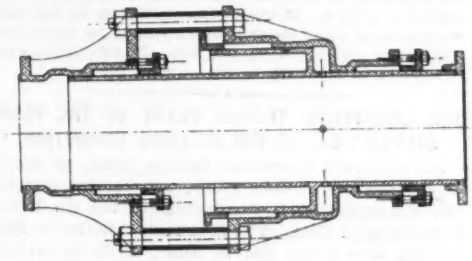


Fig. 1.

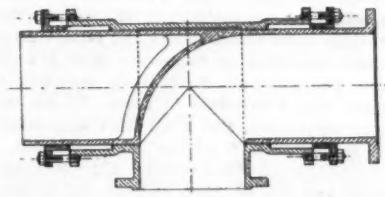


Fig. 2.

Two Approved Forms of Expansion Joints for Steam Pipes.

are brought on piping which are a constant source of danger. Expansion may not be allowed for. Joints made up where flanges do not meet fairly. Proper allowance not made for gaskets. The making up of joints before vessels are launched and no allowance having been made for possible change of form. These are a few instances of bad judgment, or carelessness of pipe-fitters, and they might be multiplied. The inspection of this piping during the time of putting in place is therefore important, and should receive the constant attention of individuals who first of all possess the knowledge of what is required, and secondly, whose duty it is to see personally that it is put in accordingly.

The third division, as classified, of the causes of failure of steam pipes is "defective material." We may consider all material defective which fails to satisfy safely the necessary conditions of its use. The failure to comply with these conditions may be due inherently to the quality of the material or to the kind of material used. For the first of these, we must hold the mill responsible, and for the second the designer. The material worked up into piping, whether of copper or steel, should be, and no doubt is, subjected to tests to prove its fitness for the purpose required. The question then arises: Are these tests sufficiently severe to develop the possible fact of weakness or positive fracture? Should it not be made an absolute certainty at the mill, that all steam piping shall stand the pressure for which it is intended? There is only one satisfactory method of doing this, and that is to subject each section of pipe to say not less than five times the working pressure required. As a matter of fact this is never done unless under direct instructions of the consignee.

As before remarked, a characteristic or tendency to split longitudinally has been observed in solid-drawn copper piping of large diameter, when subjected to high pressures, and this tendency seldom exhibits itself at the initial test. Nevertheless, the initial test will undoubtedly develop an existing weakness in however small a degree, even though that weakness be not manifest. A second or a third test at the place where the piping is installed may then fairly be expected to cause fracture in piping which is inherently weak. All steam pipe which is "made up" by the coppersmith should be tested in the same manner and as many times. The fact that a pipe fractures under a water-test pressure should never be considered a misfortune, however much it may appear so. It is a warning to be heeded, and the interpretation of the warning is to insist upon having better material and better workmanship.

I may now briefly enumerate some points in the general design, as well as the material entering into the construction of steam pipes, which will practically insure their integrity under the most severe conditions of service, if properly put together. In making a general arrangement of steam pipes two requirements of vital importance should be borne in mind, viz.: Ample allowance for expansion must be made, and, if possible, there should be no "pockets" in the steam line. "Permanent" set will occur when metals are strained beyond the limits of their elasticity, hence the absolute necessity of proper attention to "expansion." Should permanent set occur, it is only a matter of a short time till fracture takes place, due to the brittleness thus engendered. Metals of all kinds, subject to great variations of temperature and to varying strains, are constantly changing their molecular structure. In copper piping, therefore, where the elastic limit is so low, this should be neutralized by annealing the pipe at well advised intervals. The weight of piping and connections should be carried by carefully arranged hangers suspended from deck beams, spaced at frequent intervals. These should allow perfect freedom of movement, and at the same time be constructed so that the vibration will be absorbed.

An expansion joint made in either of the forms shown at Fig. 1 or Fig. 2 is a very satisfactory method of allowance for expansion, provided that there be a good packing in the stuffing-box. It will be noted that either form is perfectly balanced. There are several good packings in the market for this purpose, but one especially to be recommended is a flexible metallic packing. Stuffing-boxes for this purpose should be exceptionally deep, as it is not necessary then to pack them so tightly, and as a consequence a freer movement is permitted to the sleeve. The expansion joint shown at Fig. 1 has an enlargement cast on the sleeve. This forms a piston at the end of the sleeve adjacent to the casting having the large stuffing-box. The end of this piston next to the large stuffing-box is open, and is guided by same. In the sleeve below the piston, holes are drilled which permit the admission of live steam. The area of the piston on which the steam acts must be made equal to the area of the main steam pipe, and so while permitting perfectly free expansion, it is also perfectly balanced.

The expansion joint at Fig. 2 is more simple than that at Fig. 1, and may be used to great advantage where a right or more acute angle is required in the main steam pipe. The sleeve is simply extended through the main casting, and has a stuffing-box on both ends. In the sleeve is cast a deflecting diaphragm turning the steam into the side branch.

With the perfection to which the manufacture of steel pipe has been brought, the ideal steam pipe for high pressures has been realized. Add to this, steel flanges welded to the pipe, each pair of flanges being made male and female, and having a wire insertion gasket between them, and we have reached the acme of steam piping at the present stage of steam engineering. It is true that in mercantile work such piping with welded flanges is too expensive and difficult to get to be used in the majority of cases. A good substitute is, where the pipe is expanded into the flange and turned over into a recess, formed in the flange for this purpose. This method has the very decided advantage of being readily fitted at the place of instalment.

By kind permission of the Chief of the Bureau of Steam Engineering, I append the principal rules relating to steam pipes issued by that bureau, and which seem particularly well fitted to mercantile requirements as well as to that of the navy.

SPECIFICATIONS FOR COPPER PIPES.

1. The inspection must conform to the "General Instructions for the inspection of material under the cognizance of the Bureau of Steam Engineering."

2. The pipe must be made of Lake copper, and a chemical analysis must show that the metal is 99.5% pure copper. One analysis will be taken from each lot of 2,000 lbs. or less.

3. The pipe must be free from indentations, cracks, flaws, or other surface defects inside and outside, perfectly round, of the specified diameter and thickness in all parts. All straight sections of pipe 6 ins. in diameter (inside) or less shall be seamless drawn.

4. Each pipe must withstand an internal hydraulic pressure which will subject the metal to a stress of 6,000 lbs. per sq. in., the test pressure being calculated by the following formula for thin hollow cylinders, but in no case will a test pressure of over 1,000 lbs. per sq. in. be required:

$$p = \frac{2ts}{d},$$

in which

*From a paper read at the Meeting of the Society of Naval Architects and Marine Engineers.

†Supt. Gas Engine & Power Co., Morris Heights, N. Y.

p = safe internal pressure;
d = inside diameter in inches;
s = safe tensile strength of material = 6,000 lbs. per sq. in.
t = thickness of pipe in inches.

Every pipe must be perfectly tight under pressure and show no signs of bulging, cracks, flaws, porous places, or other defects.

5. A strip 1½ ins. wide will be taken from each lot of 2,000 lbs. or less of pipe, and must stand the following tests:

(a) If less than half an inch thick, it must stand bending flat back cold after being annealed.

(b) If half an inch and over, it must bend back after being annealed until the ends are parallel and the inner radius of the bend is equal to the thickness of the piece.

(c) In every case the ends of the bending test-pieces shall stand hammering down hot to a knife edge without showing signs of cracks.

6. Pipes of 2 ins. inside diameter and over, for steam or feed pipes or other such high pressures, are to be subject to tensile tests, one piece of pipe from each lot of 1,000 lbs. or less being selected to represent the lot. If the pipes are from 2 ins. to 6 ins. inside diameter, the test pieces are to be cut longitudinally. If over 6 ins. inside diameter, they will be cut circumferentially. The test pieces will be heated to a cherry red and straightened when hot, then machined to the shape shown (the ordinary form of 8-in. test piece.—Ed.), care being taken to have the brazed seam, if any, between the measuring points.

7. For thicknesses up to and including ¼-in., the width of the narrow part of the test piece shall be about 1½ ins. For thicker pieces the width shall be such as to give a cross section of about half a square inch, but the breadth shall not in any case be less than the thickness. The rolled surfaces are not to be machined, but to be left in their original condition.

8. The test piece must show an ultimate tensile strength, after being annealed, of at least 28,000 lbs. per sq. in. for all pipe, and an elongation of at least 25% in 8 ins. in the case of seamless pipe.

9. THICKNESS.—Every pipe must be of the specified thickness in the thinnest part. The tolerance for excess of thickness will be allowed as follows:

Pipes up to 15 B. W. G.	12%
15 to 12 B. W. G.	10%
12 to 9 B. W. G.	8%
9 to 7 B W G.	6%
7 to 00 B. W. G.	5%

10. WEIGHT.—The weight of every pipe must be at least equal to the calculated weight, on a basis of 1 cu. in. of copper pipe weighs 0.320 lb. An excess of weight equal to 5% of the calculated weight will be allowed.

SPECIFICATIONS FOR SEAMLESS STEEL AND LAP-WELDED STEEL STEAM PIPES.

1. MATERIAL.—(a) The seamless pipes must be made from solid billets or disks of perfectly homogeneous steel, and cold drawn or hot rolled, as specified in the order.

(b) The lap-welded steel pipes must be made of steel of homogeneous quality, and of the grade which is found to insure the soundest welds. The skelp must be rolled true to gage.

2. SURFACE INSPECTION.—The pipe must be free inside and outside from all surface defects which would materially weaken it or form starting points for corrosion. The defects to be especially avoided are the same as those mentioned under the head of defects in boiler tubes. The pipe must be perfectly round and vary not more than 1% above or below the gage.

3. The following tolerances will be allowed below the specified thickness:

Pipe of all diameters not over 3 ins. outside diameter, tolerance 0.01-in. below.

Pipe 3 ins. to not over 5 ins. outside diameter, tolerance 0.02-in. below.

Pipe 5 ins. to not over 7½ ins. outside diameter, tolerance 0.03-in. below.

Pipe 7½ ins. and over, 0.06-in. below.

4. WEIGHT.—The weight will be calculated from the specified dimensions and thickness, assuming that 1 cu. in. of steel weighs 0.283-lb. A tolerance of 3% under and 7% over weight will be allowed for all pipe over 4 ins. in diameter, and a tolerance of 3% under and 5% over weight will be allowed for pipe 4 ins. outside diameter or less.

5. HYDRAULIC TEST.—Every pipe must be subjected to an internal water pressure of 1,000 lbs. per sq. in., without showing signs of bulges, cracks, or other defects.

6. OTHER TESTS.—Pipe 4 ins. outside diameter and less will be tested in lots, and in the same manner as prescribed for steel boiler tubes. Pipes over 4 ins. outside diameter may be tested in lots of 10, four pipes being selected from each lot and care taken that the pipes selected for test have had the same treatment as the remainder of the lot, i. e., that they must not be annealed or softened by slow cooling unless the others have been treated in the same way. If the inspector has any doubts that the pipes have all received the same treatment he will test each pipe singly.

(a) Two test pieces will be cut circumferentially (when it is practicable to get a strip of the requisite length) from the ends of two different pipes, straightened when hot, and machined to shape and to a width of 1½ ins. For thickness up to and including ⅝-in., the length between the measuring points will be 16 times the thickness. For thickness greater than ⅝-in. the length between measuring points will be 8 ins. In the case of welded pipe, the test piece must be cut so as to leave the weld in the middle. The test must show a minimum tensile strength of 48,000 lbs. per sq. in., and an elongation of at least 12% in 8-in. or 15% in 5-in.

(b) Two test pieces of a width equal to three times the thickness of the metal in the pipe cut circumferentially from the ends of the other test pipes, so as to include the weld, if any, shall stand bending cold at the weld to an inner diameter equal to thrice the thickness of the metal without showing cracks on the outside of the bend.

7. The failure to pass these tests in a satisfactory manner will reject the lot unless the manufacturer desires to test each pipe separately, in which case a tensile test shall be taken from one end and a bending test from the other, and pipe accepted or rejected accordingly.

8. If ends of pipes are flanged, swaged down, swelled, upset or reinforced, they will be inspected after this work is done to see that no damage has been done by this process.

9. All cold-drawn pipes must be annealed in retorts or in an improved furnace in which the flame does not strike them.

10. Each pipe will be stenciled with the name of the maker and the number of the government requisition, or name of the vessel for which it is intended, and its location mark when necessary.

11. The inspector's identification stamp and the United States anchor stamp will be put on the cases in which the pipes are shipped. If the pipes are shipped in box cars containing no other freight, the cars must be sealed and the anchor stamp put on the seal. In this latter case it will not be necessary to box or crate the pipes.

THE LOCOMOTIVE TESTING PLANT OF THE PENNSYLVANIA R.R. AT THE ST. LOUIS EXPOSITION.

An elaborate locomotive testing plant, as many of our readers already know, will be installed by the Pennsylvania R, R, System at the St. Louis Exposition of 1904. The first formal notice of this project was given out in June, 1903, in letters addressed to the American Society of Mechanical Engineers and to the American Railway Master Mechanics' Association, in which these two organizations were asked to appoint each a committee of three members to coöperate with the officials of the Pennsylvania System in planning a testing plant and a schedule of tests. These committees were appointed, and since their appointment have, in coöperation with the Pennsylvania officials, completed an organization for conducting the work and settled upon its plan and scope. This organization and plan of work have just been made public in a bulletin issued by the Pennsylvania System, and as they are certain to be of wide interest, we give them nearly in full as presented in the bulletin.

PLAN AND SCOPE OF WORK.

The Pennsylvania R. R. Co. will design and cause to be constructed a suitable plant for testing locomotives, and, in co-operation with the Department of Transportation Exhibits, will install the same at St. Louis. The plant will be ready for preliminary running by March 1, 1904, and in perfect running condition by May 1, 1904, at which time formal work will commence. The purpose of the whole work is to be comprehensive and the endeavor will be to determine by the use of locomotives presenting different characteristics, the effect of the latter upon the economic performance, and the limits of the tractive power and boiler capacities.

The Pennsylvania Railroad system will organize and maintain, under the direction of its Engineer of Tests, a staff of laboratory attendants and computors, to the end that the plant and the locomotives thereon may be safely and properly operated and the experimental data promptly handled. It will also provide supplies of fuel and oil and will meet all other fixed charges incident to the progress of the work.

The Pennsylvania Railroad system, having called to its aid an Advisory Committee to assist in all matters of scientific interest, will in consultation with this committee make selection of locomotives to be tested, determine conditions under which tests are to be run, specify as to the observations to be taken and the methods to be employed, and determine the manner in which the data shall be handled and the form in which the final results shall be presented.

THE ADVISORY COMMITTEE.—While the communication of the Pennsylvania Railroad system, in response to which the members of this committee were appointed, clearly contemplates additions to the membership of the committee, those already appointed have organized, and have been required to act in formulating the provisions of this program. To avoid confusion, therefore, those already named will be regarded as "Members" of the Advisory Committee. Foreign representatives and others who may be hereafter appointed will be designated as "Affiliated Members." Members and Affiliated Members of the advisory committee shall have voice and vote alike.

THE TESTING PLANT.—The details of this plant are now being worked up by the Pennsylvania R. R. Co. It is to consist of supporting wheels upon which will be carried the drivers of the locomotives to be tested, with friction brakes on the shafts of the same, a registering dynamometer of 80,000 lbs. capacity, to which the drawbar of the locomotive will be attached, together with all necessary accessory apparatus for operating the plant and obtaining the desired data therefrom. As soon as practicable it is intended to issue a bulletin which shall completely describe and illustrate the details of the plant.

LOCOMOTIVES TO BE TESTED.—In selecting locomotives for test, an endeavor will be made to secure variety in the essential principles of design. Since the time is necessarily limited, no considerable attention will be given in attempts to analyze the action of minor details. On the contrary, the effort will be to establish the economic performance of a number of typical locomotives when operating under a wide range of conditions. No locomotive or type of locomotives will be acceptable, the value of which has not been proven by successful service on the road. Locomotives to be acceptable must have weight and power which will make them comparable in these respects with the modern American machine. It is proposed to test no locomotive which has less than 2,000 ft. of heating surface in its boiler, excepting that in case of locomotives having superheaters the superheating surface may be regarded as heating surface, and in the case of locomotives having Serve tubes, credit for the surface of the ribbing will be allowed.

The gage of the supporting wheels will be 4 ft. 8½ ins., or the same as the standard gage of American railroads, and the gage of the locomotive offered for test must be such as to run safely thereon.

It is planned to test 12 different locomotives, and it is hoped that a portion of this number can be of foreign design and construction. The time to be allowed to each locomotive will vary from 20 to 14 working days, the longer time being allowed those which are tested early in the season when both men and equipment will be new to the work. The intervals proposed are as follows: (1) May 2 to May 23, inclusive; (2) May 24 to June 13, inclusive; (3) June 14 to July 1, inclusive; (4) July 2 to July 19, inclusive; (5) July 20 to August 5, inclusive; (6) August 6 to August 22, inclusive; (7) August 23 to September 7, inclusive; (8) September 8 to September 23, inclusive; (9) September 24 to October 10, inclusive; (10) October 11 to October 26, inclusive; (11) October 27 to November 11, inclusive; (12) November 12 to November 30, inclusive.

It is not possible at this time to present a complete list of the locomotives which will be tested, but this is now under careful consideration and will be announced in a later bulletin. It is considered advisable that the owner of each locomotive presented for test should furnish a man thoroughly familiar with its working to look after the lubrication, and in general render such assistance as will insure the tests being run without interruption. The owner should also, if found necessary, provide a man thoroughly familiar with the mechanical details of the locomotive, who can advise in regard to any repairs that may be necessary during the series of tests.

FUEL.—The Pennsylvania R. R. Co. will supply for all participants two grades of coal of high quality, one an anthracite and the other a bituminous. The quality of each of these grades will remain unchanged throughout the progress of the work This composition will be approximately as follows:

	Anthracite, per cent.	Bituminous, per cent.
Volatile matter, including water....	8	20 to 22
Fixed carbon	86	69 to 74
Ash	6	9 to 6

FIREMEN.—The Pennsylvania R. R. Co. will supply men whose experience on the road will have been supplemented by special training for their work upon the testing plant. Unless otherwise arranged, these men will fire all locomotives under test. Exhibitors may, however, furnish one of their own men to give necessary instructions to the regular firemen.

THE TESTS.—It is proposed to make from 16 to 20 formal tests of each locomotive put upon the plant, these to be preceded by one or more preliminary runs for the purpose of checking the valve setting, and of proving all accessory apparatus. Each formal test will involve a run of approximately 100 miles, and throughout its duration the speed, load, steam pressure and other conditions of running will be maintained as nearly as possible, constant. The conditions represented by the several tests upon each locomotive will be so chosen that the results will fall into sets, and when so plotted will serve to disclose the performance of the locomotive under the full range of speed and cut-off for which it can be properly worked. The conditions which have been chosen for the formal tests are set forth diagrammatically by Figs. 1 and 2.

Referring especially to Fig. 1, the circles show the speed

and cut-off at which it is proposed to run the tests under a fully open throttle. Tests 1 to 4 represent a set at constant cut-off under speeds varying from 80 to 320 revolutions, the cut-off for these tests to be about 20% of the stroke. All tests of this set will be well within the capacity of the locomotive. Tests 5 to 8, inclusive, represent a second set, the cut-off for which will be made such as to make the power for test 5 the highest which can be developed at a speed of 320 revolutions. A third set at longer cut-off is made up of 9, 10 and 11. In this case the cut-off of the set is to be made such that No. 9 will give the maximum power which can be developed at a speed of 240 revolutions. Similarly, test 12 is to be made at such a cut-off as to demand the full power of the boiler at a speed of 160 revolutions, and with it will be grouped test No. 13, provided the adhesion of the drivers will permit a fully open throttle under so long a cut-off.

In case test 13 can be run, then another at a still longer cut-off, as, for example, test 14 at a speed of 80 revolutions, will be attempted. It will be apparent that tests under conditions thus chosen cover the entire range under which the locomotive may be operated with the throttle wide open. Thus, at any particular speed, an attempt to use the longer cut-off would result in a failure of the boiler to supply steam, or possibly, at the slowest speed, in the slippage of drivers. Similarly, at any particular cut-off, an attempt to operate at a higher speed would result in a failure of the boiler to supply steam. By combining the results the effect of either changes in speed or changes in cut-off in the performance of the locomotive can be readily shown.

To determine the performance of the locomotive under varying throttle openings the series 100, 101, 102 and 103 will be run. This series will be at a constant speed. The power of all tests and, consequently, the drawbar pull

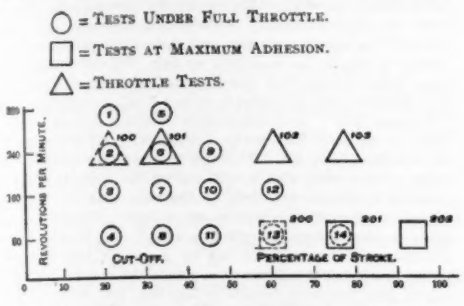


Fig. 1. Diagram of Tests of Simple Passenger Locomotives.

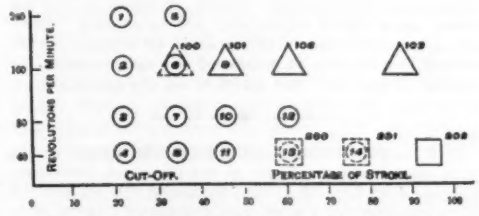


Fig. 2. Diagram of Tests of Simple Freight Locomotives.

will be constant and will be the same as that developed under a wide-open throttle in test 2. For test 101 the cut-off is lengthened and the throttle closed sufficient to make the power the same as when with the shorter cut-off, for which the throttle will be still further closed, and test 103, the longest cut-off and the throttle of the least opening for the series. It is evident that the results of this series will show the relative performance of the locomotive in doing a given amount of work under a varying degree of throttling.

Tests 200, 201 and 202 are under starting conditions. The speed of all is to be the same. For test 202 the reverse lever is to be in its extreme forward position, and the throttle opening as wide as can be allowed without danger of slipping the drivers. Test 201 is with a shorter cut-off and wider opened throttle, and test 200 with a full open throttle.

It should be evident from the explanation which has been given that the diagrams Figs. 1 and 2, do not attempt to show the actual cut-offs which will be experimented upon, nor the precise number of tests which will be necessary to define the performance of a locomotive, but rather the principles which will underlie the selection of conditions, and the relation which the several tests bear each other. The limits of performance will be different for different locomotives, and one of the tests will be to establish values for these limits.

The several speeds employed for all passenger locomotives will be those set forth in Fig. 1, so that the data for the several different locomotives will be strictly comparable.

The conditions under which freight locomotives will be tested will involve the several speeds given in Fig. 2. A comparison will show that while the range of speed for the freight locomotive is lower than that fixed for the passenger locomotive, the two sets of conditions supply ample opportunity for the inter-comparison of results which may be obtained from the two classes of locomotives.

The conditions specified for testing compound locomotives are necessarily more general than those with reference to simple locomotives, since it does not appear that any single diagram can be made which will serve to define the conditions of running with reference to compounds. For example, some of the compounds submitted for test may be of such design that a single movement of the reverse lever will change the cut-off in both the high pressure and low pressure cylinder (or cylinders). Others may be so arranged that the cut-off remains constant on the low pressure cylinder until after that upon the high pressure cylinder has been reduced to half stroke, and still others may have the control of the high pressure cut-off quite independent of that of the low pressure cut-off. No simple statement as to cut-off, or even as to number of expansions, will have the same force when applied to locomotives of these different types. Again, some of the locomotives may have no provision for using high-pressure steam in the low-pressure cylinder, while others may be equipped with a by-pass for use at low speed. Obviously, machines thus designed should be tested with the by-pass in use, as well as without it.

In view of these facts, it seems wise in case of compound locomotives, to reserve a specific statement of the conditions which are to prevail until the characteristics of each locomotive to be tested are known. The conditions which will then be proposed will be submitted to each exhibitor interested, for criticism, and finally for approval.

In the meantime, it can be said that compound locomotives will be tested under conditions which are comparable with those specified for simple locomotives. The speeds will be the same and the several tests for each speed will be under such conditions of cut-off as will disclose the performance of the locomotives under a similar range of action. The conditions to be specified for each compound locomotive will have due regard for peculiarities in its design, to the end that the power and efficiency of each machine may be demonstrated under all conditions of running which may have been contemplated in its design.

METHODS TO BE FOLLOWED IN RUNNING A TEST.—In preparation for a test, the locomotive will be started and gradually brought to the conditions of running which are to prevail throughout the test. When these conditions have been secured the preliminary running of the locomotive will be continued until the rate of firing becomes uniform and until all portions of the locomotive have become warmed to their work. When these conditions have been secured two strokes of a bell will give a preparatory signal. Thirty seconds later a singe stroke of the bell will mark the beginning of the test. Upon this stroke all water levels will be observed, the ash pan cleaned and all observations taken, and thereafter all water and fuel used will be taken from a weighed supply. Throughout the test all conditions of running will be maintained as nearly constant as possible, observations being taken on the stroke of the gong at ten minute intervals. The duration of the test will vary from two to six hours, depending upon the rate of speed and load. The element of control in fixing the length of the heavy power test will be the amount of water evaporated, no test being ended until the evaporation equals 30 lbs. for each square foot of heating surface. The lighter power tests may end after from four to six hours.

A test will be ended as it began. The fire which, throughout the test will have not changed greatly in its condition, will be brought as nearly as possible to the condition it had in the beginning, the ash pan will be cleaned, the water level in the boiler will be made to agree with that of the beginning of the test, and upon signal the final observations will be taken, and the use of water and fuel from a weighed supply will cease. As soon as practicable after this the locomotive will be stopped, the front end cleaned, and the data of the test collected and made of record.

A test will be started not earlier than 8 o'clock on each day, and when the conditions are such as will permit them to be of short duration, two tests may be run on the same day.

To avoid chances for error all important observations will be taken in duplicate by the use of independent instruments and observers. For example, the feed water will be metered and afterwards weighed, the weighings constituting the real record, and the readings of the meter the check record. The speed will be indicated by a Boyer or other speed indicator, and also by a counter which will register the revolutions, the latter supplying the real record, and the former the check record. Pressures will be observed from dial gages, and registered by a Bristol recording gage, the observed pressures constituting the real record; the recorded pressures the check. A separate indicator will be used on each end of each cylinder.

The smoke discharge above the locomotive will be so arranged as to entrap all solid matter or "sparks" passing out of the top of the stack. A chemical analysis will be made of the coal employed for each test, and of the smoke-box gases.

In the case of locomotives designed with special reference to the balance of reciprocating parts, and in the case of others, the performance of which may contrast with them, an effort will be made to study the motion (rocking, nosing, etc.,) of the locomotive as a whole while running at speed, in the hope that a definite relation will be found between the motion of the locomotive and its condition of balance.

In the case, also, of certain locomotives which will be selected with reference to their type of boiler, an effort will be made to secure a record of the direction and activity of the water currents circulating within several portions of the boiler when the latter is delivering steam, and especially of the cooler currents discharged from the injectors.

There will be obtained for each test, by direct observation, the following facts: Position of reverse lever; position of throttle; revolutions per minute; total revolutions; pounds of coal fired; pounds of non-combustible material collected in ash pan; pounds of sparks passing out of the top of the stack; time when one or both injectors are in action; pounds of water weighed to injectors; pounds of water lost by injector overflow; record of calorimeter giving quality of steam in dome of boiler; indicator cards from each end of each cylinder, and from the valve box on one side; drawbar stress as shown by dynamometer.

Pressures as follows: Of steam in boiler; of steam in branch pipe leading to cylinder; of air in the laboratory (barometric pressure); of air in ash pan; of gases in furnace; of gases in front end.

Temperatures as follows: Of the laboratory; of the feed water; of steam in branch pipe (for throttling tests only); of smoke-box gases; of water within the lower portions of the boiler at points systematically arranged.

CALCULATED OR OBSERVED RESULTS.—The organization will be such as will allow the work of the computing room to keep pace with the development of observed data in the laboratory. The data will be presented in such form as will show the facts in three different relations. (1) The performance of the locomotive as a whole, under which relation general comparisons will be based on work developed at the drawbar. (2) The performance of the boiler. (3) The performance of the engines.

By having a separate presentation of the engine and of the boiler performance it will be possible to trace the effect of each modification in design, whether in the boiler or engine; that is, changes in boiler performance resulting from changes in proportions or forms, will readily be traced, and changes in engine performance resulting from difference in design can be accredited to their proper cause. Moreover, it will be possible in the final analysis of results to interchange the boilers and engines of different locomotives, and to predict with certainty the general results which would have been obtained from a locomotive made up of any such combination. All of these facts will receive due attention in the preparation of the outline hereafter to be issued, which will govern the presentation of results.

LOCOMOTIVE ACCESSORIES.—Locomotives submitted for test must be equipped with such accessory apparatus as may be necessary for the attachments of all instruments of observation, so that there need be no delay in getting the locomotive into operation after it is received at St. Louis. Such accessory apparatus will consist chiefly of indicator plugs for cylinders and valve box, a water gage glass for locating the height of water in the boiler, reducing motions for indicators, plugged openings into the boiler front end, pipe connections which will serve in the attachments of gages, thermometers and gas samplers, a light return crank for the attachment of a Boyer speed recorder, and a registering counter, a drilled coupling pin hole in the foot plate, with a pin turned to fit, and provision for lubricating all journals when the locomotive is in motion. The exact character of each of these details will be made the subject of a later announcement.

PUBLICATION OF RESULTS.—In order that the results may serve the largest purpose possible it is proposed to issue publications as follows:

(1) Bulletins of Announcement. These will constitute the communications of the Pennsylvania Railroad system and its advisory committee to the public, with reference to their plans and purposes. They will give information to those who may exhibit locomotives for test, and it is hoped that they will draw from those who are interested, such suggestions or criticism as will assist in furthering its work.

(2) Bulletins of Results. These will be issued from time to time, and will constitute formal reports of the performance of individual locomotives. It is expected that when tests upon a given locomotive have been completed

the results obtained, and such analysis of performance as may be based thereon, will be entirely set forth in a bulletin.

(3) A formal publication to be issued at the conclusion of the whole work, presenting in such form as may be hereafter determined, the facts and conclusions developed by the whole study.

ORGANIZATION.

THE PENNSYLVANIA R. R. SYSTEM.—J. J. Turner, Third Vice-President, Pennsylvania Lines West of Pittsburg; Theo. N. Ely, Chief of Motive Power, Pennsylvania R. R. System; F. D. Casanave, Special Agent, Pennsylvania R. R. System; E. D. Nelson, Engineer of Tests, Pennsylvania R. R. Co., Altoona, Pa.

LOUISIANA PURCHASE EXPOSITION.—Willard A. Smith, Chief of the Department of Transportation Exhibits, Louisiana Purchase Exposition.

ON BEHALF OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—W. F. M. Goss, Dean of the Schools of Engineering, Purdue University; Edwin M. Herr, General Manager, Westinginghouse Air Brake Co.; J. E. Sague, Mechanical Engineer, American Locomotive Co

ON BEHALF OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.—F. H. Clark, Supt. of Motive Power, Chicago, Burlington & Quincy R. R.; C. H. Quereau, Supt. of Shops, New York Central & Hudson River R. R.; H. H. Vaughan, Asst. Supt. of Motive Power, Lake Shore & Michigan Southern Ry.

OFFICERS.—F. D. Casanave, Special Agent of the Pennsylvania R. R. System; W. F. M. Goss, Chairman of the Advisory Committee; H. H. Vaughan, Secy. of the Advisory Committee.

ELECTRIC MACHINERY FOR THE NEW YORK CENTRAL terminal improvements at New York city has just been ordered, as noted in the statement printed below. For the generating station, steam turbines have been adopted, in units of 7,500 HP., which is as large as the largest steam engines now operating, though both reciprocating engines and steam turbines of greater size are now being built. The electric locomotives which will haul the trains over the terminal division have also been ordered. The General Electric Co., of Schenectady, N. Y., who have received the contracts for the steam turbines and generators, as well as the locomotives, have furnished us the following statement relative to the order:

The New York Central & Hudson River R. R. Co. have placed an order with the General Electric Co. for eight turbo-generators, of a capacity of 7,500 HP. each. The turbines are of the four-stage vertical Curtis type. The generators are 25 cycle, three-phase, generating current at a pressure of 11,000 volts. This is by far the largest order for steam turbines ever placed in this country or abroad.

The New York Central Co. has also placed with the General Electric Co., in co-operation with the Schenectady Works of the American Locomotive Co., an order for 30 electric locomotives. These locomotives are of an entirely new design and will weigh 85 tons each, with an adhesive weight on the drivers of 67 tons. Each locomotive will have a capacity of 2,200 HP. and will be capable of hauling a train of 500 tons at a speed of 60 miles an hour. This is by far the largest order for electric locomotives ever placed in any country.

It will be remembered that the electric locomotives of the Baltimore & Ohio Ry. operating trains through the Baltimore tunnel, which were also built by this company, have all (four) axles driven, giving the total weight for adhesion. According to the above statement the New York Central locomotives will have only about 80% of the total weight on driving wheels.

THE NUMBER OF PASSENGERS CARRIED in New York City by the different roads is given in a report of the Railroad Commissioners, dated Nov. 5, from which the following has been abstracted:

Passengers Carried, Including Transfers, for Three Months Ending Aug. 31, 1902-3.

Borough.	1902.	1903.	Difference.
Manhattan	193,779,987	206,267,066	Inc. 12,487,079
The Bronx	13,093,676	12,600,289	Dec. 493,387
Brooklyn	99,427,258	106,690,744	Inc. 7,263,481
Queens	6,188,603	6,077,911	Dec. 110,692
Richmond	3,125,567	3,204,558	Inc. 78,991
Total	315,615,091	334,840,568	Inc. 19,829,556
			Dec. 604,079
Total increase			19,225,477

Car Mileage.

Borough.	1902.	1903.	Difference.
Manhattan	28,122,843	32,531,260	Inc. 4,408,417
The Bronx	1,751,674	2,043,119	" 291,445
Brooklyn	16,131,734	17,768,605	" 1,636,871
Queens	1,035,974	1,037,579	" 1,605
Richmond	685,004	713,470	" 28,463
Total	47,727,229	54,094,033	Inc. 6,366,804

Total Number of Passengers Carried, Including Transfers, for Three Months Ending Aug. 31, 1902-3.

	1902.	1903.	Difference.
Interborough Rapid Transit	50,227,204	58,885,736	Inc. 8,658,532
Interurban	143,552,783	147,381,330	" 3,828,547
Total	193,779,987	206,267,066	Inc. 12,487,079

Total Car Mileage.

	1902.	1903.	Difference.
Interborough	11,155,305	14,820,548	Inc. 3,665,243
Interurban	16,967,538	17,710,712	" 743,174
Total	28,122,843	32,531,260	Inc. 4,408,417

Passengers Carried, Including Transfers for Three Months Ending Aug. 31, 1902-3.

Railroad.	1902.	1903.	Difference.
Bklyn Hgths. Co.	86,250,306	94,049,396	Inc. 7,789,090
Coney I. & Bklyn	12,806,631	12,227,887	Dec. 578,744
Van Brunt St. & Erie Basin	300,321	413,461	Inc. 53,140
Total	99,427,258	106,690,744	Inc. 7,842,230
			Dec. 578,744
Net increase			7,263,486

AN UNDERGROUND ELECTRIC RAILWAY of the tube type is approaching completion in London, England, and differs in several respects from the existing "tube" lines in that city. The line is known as the Great Northern & City Ry., and extends from Moorgate St., in the heart of the city, to Finsbury Park, where it connects with the main line of the Great Northern Ry. The total length is 3½ miles, and the average depth below the surface is 60 ft., with a maximum depth of 75 ft. The diameter is much larger than that of the other lines, being 16 ft., with a special view to hauling the ordinary main line and suburban cars. There are two parallel single-track tunnels, and these have the lower section of brick, while the upper section is built up of cast-iron segments. Another feature is the use of the third-rail system, supplemented by a fourth rail for the return circuit, both of these rails being outside the track rails. The trains are operated on the multiple unit system, and the cars are of the vestibuled pattern, 49¼ ft. long, mounted on four-wheel trucks. At the middle of each side is a sliding door, to be used only at terminals. Automatic signals will be installed, and the stations will be fireproof throughout; the patforms will be of concrete, and the stairs, seats, signal cabins, etc., will be of steel. Emergency gas lights are to be placed at all stations, so arranged that in case of failure of the electric light, the turning of one valve will throw on all the gas lights.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision on the Cleveland, Cincinnati, Chicago & St. Louis Ry., near Mackinaw, Ill., on Nov. 19. A freight train and a work train collided on a sharp curve in deep cutting. Twenty persons were killed and many others seriously injured. All the killed were passengers on the work train. The collision is chargeable to a disregard of orders by the freight train, due probably to an imperfectly worded order. It is worth noting that this is the fourth unusually disastrous railway wreck within five weeks: The list is, in order, (1) Oct. 17, at Washington Crossing, N. J. (rear collision), 17 killed; (2) Oct. 31, at Indianapolis, Ind. (butting collision), 16 killed; (3) Nov. 14, at Kentwood, La. (rear collision), 31 killed; and (4) Nov. 19, Mackinaw, Ill. (butting collision), 20 killed. Three of these four were accidents to work trains, and in each case the section laborers on the work trains furnished nearly the whole number of victims. The fourth—the Indianapolis accident—involved a special passenger train, and but for the peculiar nature of the collision, the side of the train being struck by a cut of cars coming out of a siding, the accident would not have been serious.

A FATAL ELEVATED RAILWAY COLLISION occurred on Nov. 19 on the Fifth Ave. line of the Brooklyn Rapid Transit Co., in Brooklyn, New York city. A westbound train became stalled through blowing of its fuse and a following train ran into it. The trains were set on fire from a short-circuit caused by the wreck. Two persons, the motorman and a guard of the second train, were killed, and a number of others were injured. The collision occurred shortly after 5 p. m., when it was not yet quite dark; this, together with the fact that the forward train had red tail-lights burning, makes it impossible to assign a definite cause for the accident.

FAILURE OF THE SEA WALL AT VICTORIA, B. C., is reported as slowly taking place, due to the thrust of mud pumped in behind it by the hydraulic dredge "King Edward."

AN OUTBREAK OF TYPHOID FEVER AT WILLIAMS College, Williamstown, Mass., has caused the authorities to secure the services of Mr. Geo. H. Soper, Assoc. M. Am. Soc. C. E., and Dr. W. H. Park, a specialist in bacteriology and communicable diseases, for the purpose of investigating and suppressing the causes of the disease. Up to Nov. 19 seven students were ill with the disease at the college infirmary, one was down with it at home, and four others were suspiciously ill.

DAMAGES FOR WATER POLLUTION have been awarded in a jury trial in a suit brought by Rose B. Edwards against the proprietors of the reduction plant which treats the garbage of Columbus, O. The complainant alleged that liquid wastes from the works so polluted the water of Alum Creek that stock would not drink therefrom and that unpleasant odors were caused by the wastes. The jury awarded damages to the amount of $1,354. The defendant claims that the pollution of Alum Creek is largely due to the discharge from some of the sewers of Columbus. The defendants have filed a motion for a new trial.

AN ILLINOIS GOOD ROADS COMMISSION has been appointed by Governor Yates. Mr. De Witt Smith, of Springfield, is chairman; the other members are Mr. Charles D. Clark, of Peoria, and Mr. H. U. Wallace, Chief Engineer of the Illinois Central R. R.

A LARGE BLAST was fired on the Columbia River, about 20 miles above Astoria, Oregon, Oct. 28. Sixty tons of dynamite were fired in three blasts of 20 tons each, for the purpose of securing rock for the jetty at the mouth of the Columbia River. The face of a bluff was torn away with a shock that was felt for miles around, and some 100,000 tons of granite were thrown down. The Northwestern Construction Co. have the contract for furnishing the rock.

HYDRAULIC OPERATING MECHANISM FOR BULKhead doors, of what is known as the Stone-Lloyd design, built by J. Stone & Co., of Deptford, England, has been fitted to a number of the fast trans-Atlantic passenger steamers within the past year or two. The installation on the "Deutschland," of the Hamburg-American line, was described in a recent number of our London contemporary, "Engineering." The doors slide vertically, and have a rack on the outer face which meshes with a driving pinion on a horizontal shaft. Through intermediate gearing this shaft is connected with a rack cut on the plunger rod of a vertical hydraulic cylinder, so that the door is closed or opened as the plunger moves up or down. Water is supplied to the hydraulic cylinders of all the doors from a steam-loaded accumulator fed by a duplex high-pressure pump located in a safe position above the water-line. The water pressure used is 600 to 700 lbs. per sq. in. Near each door is located a valve-mechanism which by a plain slide or D-valve (held to its seat by the supply pressure) connects the supply or the exhaust pipe to either end of the cylinder. The valve is moved by a small piston, arranged so that water may be admitted to either side. One side of this piston is of greater effective area than the other, and the connections are such that water admitted to this side acts to move the valve in the direction which effects a closing of the door. The result of this is to close the door or keep it closed when water is admitted to both sides of the valve-piston. This is necessary since three separate means are provided for actuating the valve to close the door. The pipes supplying the operating piston of the valve lead to the bridge of the vessel, where they are controlled by a valve; opening this valve acts to close all the bulkhead doors throughout the vessel. Secondly, at each door is a lever by which pressure-water can be admitted on the "closing" side of the operating piston of that valve, so as to close that door alone. Thirdly, a small tank, is placed near each door, with small openings connecting to both sides of the bulkhead; a float in this tank, when raised by water entering, releases a weight which in falling opens a connection between the supply-pipe and the "closing" side of the operating piston of the valve, thereby automatically closing the door. The proportioning of the parts is such that the doors move slowly and with considerable power to overcome obstructions. When the doors are closed from the bridge, by the means already noted, persons may be caught in a compartment without means of exit. To enable such persons to open momentarily the door to the next compartment, the operating-piston of the valve of each door has a small needle-valve which may be opened by a lever having a handle on each side of the bulkhead; this needle-valve allows the pressure-water on the "closing" side of the operating-piston to escape to the exhaust, thereby returns the main valve to "opening" position and causes the door to rise. As soon as the lever is released the needle-valve is closed by a spring, and the main valve is forced back, thereby again closing the door. Our source of information states that the piping used in this system of mechanism is 1¼, 1½ and 2½-in. copper pipes, with bronze flange-joints packed with dermatine. We are unable to gather, however, how complex a system of piping is required to connect the various valves with the central control. We may note that a hydraulic bulkhead door mechanism was described in Engineering News of Aug. 18, 1898, and an electric mechanism was noted in a paper read before the Society of Naval Architects and Marine Engineers, briefly abstracted in our issue of Nov. 23, 1899.